

BIOLOGICAL RESOURCES RESPONSES

Request #34 - Please provide a copy of the wet season survey results within ten business days after completion of the final survey. The report shall indicate the biologist's survey permit and conditions of that permit, if any, per USFWS guidelines.

Response #34 - Responses #14 and #16 to the Data Adequacy Responses (DARs, filed with the CEC on 12-4-01) to the AFC identifies that all direct and indirect impacts to seasonal wetland (fairy shrimp) habitats will be avoided via trenchless construction methods, facility siting outside of potential habitat boundaries, or by installing linear facilities within existing road right of ways (Figure B-2). The proposed alignment of linear facilities does not coincide with seasonal wetland habitat that may be occupied by the vernal pool fairy shrimp (*branchinecta lynchi*). A copy of the wet season survey results for fairy shrimp sampling will be submitted within ten business days after completion of the final survey. The report shall indicate that sampling was conducted by Frank Wegscheider (USFWS Branchiopod Permit # TE-038716) per United States fish and wildlife service recommended guidelines.

Request #35 - Please prove the USACE field report and determination of jurisdiction.

Response #35 - Responses #14 and #15 to the data adequacy responses (DARS) to the AFC (filed with the CEC on 12-4-01) identifies that all impacts to USACE potentially jurisdictional features will be avoided. On 19 October 2001 the applicants representative project biologist Lenny Malo (949-756-7556), California Energy Commission representative Shari Koslowsky (818-597-3547 extension 309), and USACE representative Robert Smith (213-452-3419) completed a field survey to verify / confirm the results of the applicant's surveys. It was determined that the project impact area will not directly or indirectly impact any USACE potential jurisdictional features (wetlands or waters of the U.S.). It was therefore determined in the field that a USACE permit was not necessary. All USACE potential jurisdictional features and waters of the U.S. within the San Jacinto River 100-year flood plain will be avoided through the use of trenchless construction methods, siting the facilities outside of potential habitat or jurisdictional feature boundaries, or by installing linear facilities within existing road right of ways. Please contact project biologist Lenny Malo (949-756-7556), CEC representative Shari Koslowsky (818-597-3547 extension 309), or USACE representative Robert Smith (213-452-3419) if further clarification is needed.

Request #36 - Please provide a description of construction measures and placement of structures that demonstrate avoidance of wetlands and defined bed and bank features consistent with the findings of the USACE field report and Figure B-2 (IEEC 2001b).

Response #36 - Responses #14, #15, and #16 to the DARs (filed 12-4-01) to the AFC describes the measures and placement of structures that demonstrates avoidance of wetlands and defined bed and bank features. USACE potentially jurisdictional features (wetlands and waters) will be avoided via trenchless construction methods, facility siting outside of potential habitat boundaries, or by installing linear facilities within existing road right of ways.

Request #37 - Provide a map of wetlands or other jurisdictional features in greater detail than that provided in the AFC that is compatible with the quantification of wetlands to one-tenth of an acre presented in the text. The scale should also be consistent with the information provided in data request 3. Wetland features at the corner of Murrieta and McLaughlin Road are misplaced

and the defined bed and bank features identified within the project area have not been geographically identified. The estimate of wetland acreage affected by the transmission line and non-reclaimable wastewater pipeline in Table 5.3-7 (0.5 acres) and the text in page 5.3-32 (0.8 acres) of the AFC are inconsistent. These inconsistencies and omissions should be corrected as they detract from the conclusions provided in the document and are necessary for staff to appropriately assess mitigation of potential impacts.

Response #37 - The estimate of wetland acreage affected by the transmission line and non-reclaimable wastewater pipeline in AFC Table 5.3-7 (0.5 acres) and the text at AFC page 5.3-32 (0.8 acres) of the AFC are inconsistent. These inconsistencies and omissions have been corrected. A corrected Table 37-1 has been created and supercedes AFC Table 5.3-7. Table 37-1 is now consistent with the DARs (filed 12-4-01) to the AFC which identifies that all impacts to seasonal wetlands will be avoided via trenchless construction methods, facility siting outside of potential habitat boundaries, or by installing linear facilities within existing road right of ways (DARs, Figure B-2). The revised table is presented below.

Table 37-1 Linear Facilities Construction Corridor Wetland Areas

Linear Feature	Wetland Description	Within the CC (acres) ⁽¹⁾
Non-Reclaimable Wastewater Pipeline⁽²⁾:		
Both sides of McLaughlin Road	Seasonal wetland, natural and agricultural drainage	0 acres
Transmission Line⁽³⁾:		
North side of McLaughlin Road west of Palomar Road	Seasonal wetland, natural and agricultural drainage	0 acres
North side of McLaughlin Road east of Palomar Road	Seasonal wetland	0 acres

(1) CC – construction corridor; acres rounded to nearest 0.1 acre

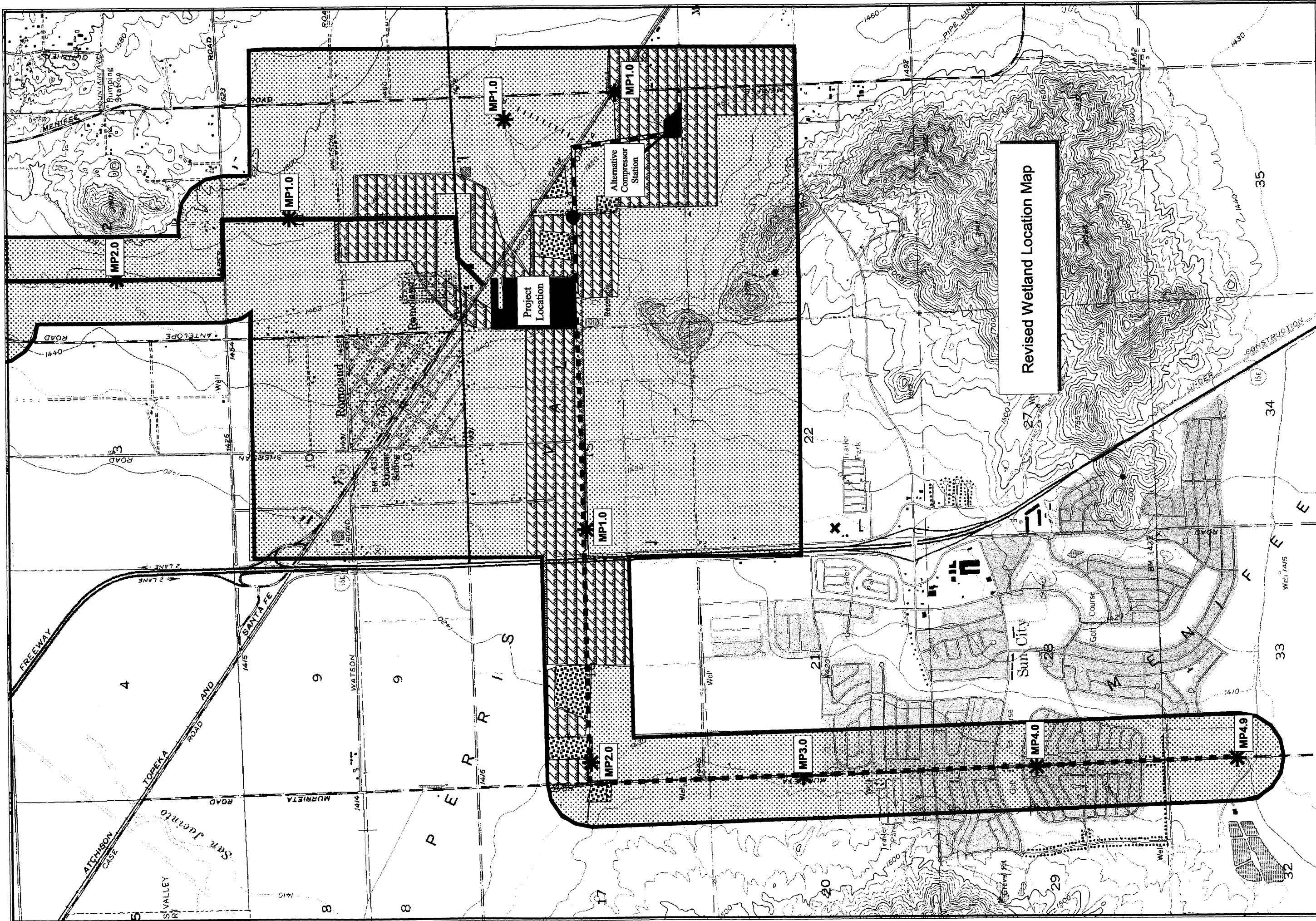
(2) Construction corridor width outside of the road = 20 feet

(3) Five structures averaging 10,000 square feet each and two pull sites averaging 10,000 square feet each

Wetland features at the corner of Murrieta and McLaughlin Road were misplaced in the original AFC. Please see the corrected Figure 37-1 which supercedes AFC Figure 5.3-2A.

Request #38 - Provide a discussion of the types of nitrogen generated as a result of the project and confirm that the modeled deposition rates at Class I wilderness areas in Table 5.3-11 are based on a worse case analysis of the maximum NO_x and ammonia emissions that could occur during plant operation. Provide an isopleth graphic over a USGS 7.5 minute quadrangle maps (or equally detailed map or more current map) of the direct deposition values (not weighted average). Provide complete citations for all references used in this analysis.

Response #38 - The maximum NO_x and ammonia emission rates expected for the project are summarized on Tables 5.2-21, K-9-1, and K-9-2 of the AFC. These NO_x and ammonia emission rates were used for the nitrogen and sulfur deposition modeling performed for the project and that are summarized on Table 5.3-11 of the AFC. Enclosed, as Bio Attachment 1 is a map showing the nitrogen deposition isopleths for the project.



Revised Wetland Location Map

LEGEND

	Urban/Exotic/Residential		Alkali Playa		Natural Gas Pipeline (Alt. A)
	Riparian/Permanent Wetland		Annual Grassland		Natural Gas Pipeline (Alt. B)
	Seasonal Wetland		Agriculture		Transmission Line
			Water Crossing		Water Pipeline

0 1000 2000 3000 4000 5000 6000 Feet

Inland Empire Energy Center

Figure 37-1

Natural Communities

Request #39 - Provide the ambient/background levels in the project area and the Class I wilderness areas, and the source for this information (e.g., a complete copy of the papers or reports cited).

Response #39 - Atmospheric deposition of nitrogen (N) derived from the California Acid Deposition Monitoring Program (CADMP) indicates that N deposition to agricultural soils at the county level ranges from <1 to 14 kg/Ha/yr. Findings from this early study (Abstract 95-17) indicates that there is a limited possibility that atmospheric deposition of N would be an important contributor to a buildup of soil nutrients that could cause adverse effects on crop productivity, and that nutrient deposition values in the range of 15 kg/Ha/yr could have pronounced effects on plants in natural, unmanaged ecosystems, such as grasslands or forests, that are adapted to growing in nutrient poor conditions.

Data reported by Envair (Abstract 96-13) indicates a wet nitrate deposition rate for almost the entirety of the South Coast Air Basin in the range of 2-4 kg/Ha/yr, and a dry nitrate deposition rate which varies from 1 to 86 kg/Ha/yr from the coastal region of the basin (Long Beach) to the inland areas (Azusa). Nitrogen deposition values based upon emissions of oxidized nitrogen species ranged from ~12 to 25 kg/Ha/yr. This report also suggests that dry deposition trends should be carried out based on the emissions (ambient air concentrations) rather than the dry-deposition flux methods due to the uncertainties in the process of calculating the fluxes.

Data compiled by the USDA and DRI (Abstract 97-5) from a mountain site (Barton Flats) downwind of the metropolitan LA area, which may be typical of the Class I areas delineated in the AFC (Air Quality Section) showed dry N deposition rates using three different sampling and analysis methods to be in the range of 2-14 kg/Ha/yr. Follow-on research by the USFS (Abstract 98-5) at two other sites in the San Bernardino Mountains (Camp Paivika and Camp Osceola) was also conducted. Annual rates of total N deposition at Camp Paivika were approximately 32 kg/Ha/yr, with wet deposition (fog) being an important source of nitrogen to forests at the western end of the San Bernardino Mountains.

Based on the above, it is expected that the plant site region would experience wet N deposition values of 2-4 kg/Ha/yr and dry N deposition values (based on emissions oxidation) of 12-25 kg/Ha/yr. Data collected from the National Atmospheric Deposition Program (NADP) for the Joshua Tree National Park (Class I area) indicates a nitrate deposition rate (NO_3) of 0.10 kg/Ha/yr, and an ammonium (NH_4) deposition rate of 0.02 kg/Ha/yr. Tables 39-1 and 39-2 delineate the NADP data for the Joshua Tree Park site. Data for the Cucamonga Wilderness Area (Tanbark Site) is delineated in Table 39-3 and Figures 39-1 and 39-2. Data for the other identified Class I areas was not available.

References:

Effect of Acid Deposition on Man-Made Materials, Valley Research Corporation, et.al., Contract #A6-079-32, California Air Resources Board, Research Abstract 93-3.

Preliminary Findings of the California Acid Deposition Monitoring Program, Desert Research Institute, Reno, Nevada, Contract #A6-076-32, California Air Resources Board, Research Abstract 94-4.

Application of Models to Predict Acidity Changes in the Alpine Watersheds in the Sierra Nevada, U.S Geological Survey, Contract #A932-076, California Air Resources Board, Research Abstract 94-8.

Effects of ozone and Acidic Deposition on Gas Exchange Responses in Ponderosa Pine, University of California Berkeley, USDA, Contract #A132-101 and A132-174, California Air Resources Board, Research Abstract 95-7.

Detail in Support of Direct Free-Radical Measurements in Polluted Urban Air, Unisearch Associates, Contract #92-327, California Air Resources Board, Research Abstract 95-8.

Atmospheric Deposition to Agricultural Soil, University of California Riverside, Contract #93-334, California Air Resources Board, Research Abstract 95-17.

Acid Deposition Rates in California, Envair, Contract #A132-149 and 93-332, California Air Resources Board, Research Abstract 96-13.

Effects of Nitrogen Deposition on a Mixed Conifer Forest, USDA, Desert Research Institute, Contract #A032-180 and 92-335, California Air Resources Board, Research Abstract 97-5.

Nitrogen Saturation in the San Bernardino Mountains, USFS, Contract #95-329, California Air Resources Board, Research Abstract 98-5.

Copies of the abstracts noted above are included in Bio Attachment #2.

Request #40 - Provide a matrix of projects considered in the cumulative air quality analysis proposed in Section 5.2.5 of the AFC. In your results, indicate the amount of nitrogen deposition from the cumulative projects using the values tons per year and kg/ha-yr. The matrix should include the source's distance and direction from the proposed power plant, the amount of NO_x emitted using the values tons per year and kg/ha/yr, and a short description (or assumptions made) of the sources. Once all projects have been identified, using the ISCST3 model, provide the cumulative nitrogen deposition on the Class I wilderness areas identified in Table 5.3-11 of the AFC. Provide an isopleth graphic over a USGS 7.5 minute quadrangle maps (or equally detailed map or more current map) of the direct deposition values (not weighted average). Please note that Data Request #40 addresses this issue as well.

Response #40 - The detailed information regarding the cumulative air quality impact analysis performed for the project is included in the data adequacy responses submitted to the CEC on November 30, 2001 at the end of Attachment 1. This information includes a list of the new/proposed emission sources in the project area, the distances from these sources to the project site, the detailed emission calculations, stack parameters, and modeling results. IEEC is in the process of performing an analysis of the cumulative nitrogen deposition impacts from these sources. This analysis will be submitted to the CEC as soon as it is completed.

Request #41 - The applicant should describe how the compressor station would be connected to the electrical grid and whether this connection would require additional distribution lines or poles. If distribution lines are needed, describe impacts to wildlife and protections against electrocution that will be installed.

Response #41 - The proposed location for the compressor station is on the north side of Rouse Road (dirt road), 600 feet west of the intersection of Rouse Road and Menifee Road. The compressor station will be owned by So-Cal Gas and will be supplied electricity by

Southern California Edison (SCE). At present, SCE is considering both 33kV and 4160V connections. The point of electrical interconnection to the compressor station, whether a 33kV line to a substation built at the compressor station or a 4160 V line to the compressor station power house, would be at a point approximately 250 feet north and 1000 feet west of the intersection of Rouse Road and Menifee Road. SCE is currently evaluating these options. The County of Riverside has an ordinance to underground utilities under 33kV, but since SCE will own this line, the line may not be subject to County regulation. It is envisioned that SCE would design and construct this line with all of their standard wildlife and electrocution protections. The applicant would be pleased to provide more detailed information as soon as it is received from SCE after the completion of their evaluation.

Request #42 - Please provide a detailed outline of the “Biological Resources Mitigation Implementation and Monitoring Plan” (BRMIMP) which includes the applicant’s biological resources mitigation measures and the HCP’s incidental take measures for Stephen’s kangaroo rat (Riverside County Habitat Conservation Agency 1996).

Response #42 - Impacts to biological resources have been minimized to the maximum extent practical by eliminating the Alternative B Moreno Valley Gas Pipeline, siting facilities away from sensitive habitats (within disturbed agricultural fields, within existing roads, etc) and the use of trenchless technology to avoid direct and indirect impacts to USACE and CDFG jurisdictional features. In addition to the mitigation measures incorporated into the project design (use of trenchless construction methods, facility siting outside of potential habitat boundaries, and installing linear facilities within existing road right of ways), the Applicant has proposed the following mitigation measures to reduce potential impacts to biological resources to a level of insignificance.

- The Applicant will designate a project biologist to manage all biological resource conditions of certification.
- The Applicant will develop and institute an Employee Environmental Awareness Program to inform construction and operations workers about biological resources associated with the project.
- The Applicant will provide funds for impacts to historic SKR habitat within the Fee Area in accordance with the requirements of the HCP for the SKR (Energy Center site; Alternative A Menifee Road natural gas pipeline MP 0-0.9 and associated compressor station site; transmission line MP 0-0.9; and non-reclaimable wastewater line MP 0-4.7).
- The Applicant will avoid all direct and indirect impacts to seasonal wetland habitats via trenchless construction methods, facility siting outside of potential habitat boundaries, or by installing linear facilities within existing road right of ways.

Proposed BRMIMP outline would be as follows:

- A project description, construction schedule, and a schedule of the environmental compliance activities described in the background documents;
- Responsibilities of participants, qualifications of biological monitors, and communication protocols;
- An employee education program;
- Pre-activity measures and reporting;

- Environmental compliance monitoring and reporting;
- Post-construction cleanup and reclamation requirements;
- Compensation; and
- Mitigation measures to be carried out during O&M of the project.

With respect to the incidental take measures for SKR, a request to the RCHCA for a copy of the “take permit” provisions was made on 2-11-02. This data will be supplied to CEC staff on 2-20-02.

Table 39-1

National Atmospheric Deposition Program/National Trends Network
2000 Annual & Seasonal Data Summary for Site CA67
Part 1: Summary of Sample Validity and Completeness Criteria
(Printed 09/14/2001)

Site Identification		Sample Validity for Annual Period	
Site Name	Joshua Tree National Park-Black Rock	Number of samples	14
		Valid Samples	14
Site ID	CA67	with precipitation	7
State	CA	with full chemistry**	3
County	San Bernardino	without chemistry	4
Operating Agency	NPS	without precipitation	7
Sponsoring Agency	NPS	Invalid Samples	0
		with precipitation	0
		missing precipitation data	0
Latitude	34:04:17		
Longitude	116:23:26		
Elevation	m		

Summary Period Information			
	<u>Annual*</u>		<u>Fall*</u>
First summary period day#	01/04/2000		08/29/2000
Last summary period day	01/02/2001		11/28/2000
Summary period duration	364		91
Number of samples	14		10
Measured precipitation (cm)	0.6		0.6
Valid samples with full chemistry**	3		3
Valid field pH measurements	1		1

NADP/NTN Completeness Criteria			
	<u>Annual*</u>		<u>Fall*</u>
1.Summary period with valid samples (%)	29		77
2.Summary period with precip coverage (%)	29		77
3.Measured precipitation with valid samples (%)	100		100
4.Collector efficiency (%)	123		123
Precip with full chemistry and valid field pH (%)	28		28

* = Data do not meet NADP/NTN Completeness Criteria for this period.

** = Valid samples for which all Laboratory Chemical measurements were made (The ONLY samples described by the percentile distributions in the Statistical Summary of Precipitation Chemistry for Valid Samples).

*** = Measured precipitation for sample periods during which precipitation occurred and for which complete valid laboratory chemistry data are available

= Summary period start and end days do not correspond to the first or last sample day.

**National Atmospheric Deposition Program/National Trends Network
2000 Annual & Seasonal Data Summary for Site CA67**

Part 2: Statistical Summary of Precipitation Chemistry for Valid Samples

Precipitation-Weighted Mean Concentrations

	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	mg/L											
Annual*	1.15	0.178	0.066	0.703	0.40	1.72	1.05	0.77	1.97E-03	3.72E-03	5.71	5.43
Fall*	1.15	0.178	0.066	0.703	0.40	1.72	1.05	0.77	1.97E-03	3.72E-03	5.71	5.43

Deposition

	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	kg/ha											
Annual*	0.07	0.010	0.004	0.041	0.02	0.10	0.06	0.04	1.14E-04	2.15E-04	--	--
											--	--
											--	--
Fall*	0.07	0.010	0.004	0.040	0.02	0.10	0.06	0.04	1.11E-04	2.10E-04	--	--

Weekly Sample Concentrations

	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	mg/L											
Minimum value	0.05	0.011	0.014	0.049	0.30	0.88	0.08	0.19	1.86E-04	2.95E-04	4.89	5.43
Percentile 10	0.02	0.004	0.006	0.020	0.12	0.35	0.03	0.08	7.45E-05	8.85E-05	1.96	1.63
Percentile 25	0.05	0.011	0.014	0.049	0.30	0.88	0.08	0.19	1.86E-04	2.21E-04	4.89	4.07
Percentile 50	0.71	0.195	0.064	0.181	0.43	1.71	0.16	0.77	1.91E-03	2.01E-03	5.72	5.98
Percentile 75	1.80	0.600	0.244	5.894	0.59	4.40	9.49	2.60	1.29E-02	2.79E-03	6.73	4.90
Percentile 90	0.72	0.240	0.098	2.358	0.24	1.76	3.80	1.04	5.15E-03	1.11E-03	2.69	1.96
Maximum value	1.80	0.600	0.244	5.894	0.59	4.40	9.49	2.60	1.29E-02	3.72E-03	6.73	6.53
Arithmetic mean										--		--
Arith. std dev											--	--
Below detection									--	--	--	--

Other Parameters

	Measured Precipitation*** cm	Conduc- tivity uS/cm	Equivalence Ratios		
			<u>SO4</u>	<u>SO4+NO3</u>	<u>Cation</u>
			NO3	H	Anion
Minimum value	0.51	4.6	0.28	9.53	1.00
Percentile 10	0.20	1.8	0.11	3.81	0.40
Percentile 25	0.51	4.6	0.28	9.53	1.00
Percentile 50	1.60	15.8	0.58	9.70	1.21
Percentile 75	3.05	56.9	0.76	234.04	2.91
Percentile 90	1.22	22.8	0.31	93.61	1.16
Maximum value	3.05	56.9	0.76	234.04	2.91

Annual and Seasonal Equivalence Ratios

	<u>SO4</u> NO3	<u>SO4+NO3</u> H	<u>Cation</u> Anion
Annual*	0.58	22.16	1.76
Fall*	0.58	22.16	1.76

Please see page 1 for footnotes.

Table 39-2

National Atmospheric Deposition Program/NTN
Annual/Seasonal Depositions

Site ID	Summary Period	Year	Data Completeness Criteria (%)				Deposition (kg/ha)											Totals		% Precip. Represented by Field Chem.	Valid Samples		Days	Dates	
			1	2	3	4	Ca	Mg	K	Na	NH ₄	NO ₃	Inorganic N	CL	SO ₄	H+ (Lab)	H+ (Field)	Sample Vol. (ml)	Precip (cm)		L	F			
CA67	Annual	2000	27.0	29.0	47.0	43.0	0.01	0.009	0.004	0.084	0.02	0.10	0.04	0.14	0.04	0.00	0.00	151.8	0.58	28.00	2	1	364	09/19/2000	01/02/02

Table 39-3

National Atmospheric Deposition Program/National Trends Network

1998 Annual & Seasonal Data Summary for Site CA42

Page 1: Summary of Sample Validity and Completeness Criteria

(Printed 08/29/2000)

Site Identification		Sample Validity for Annual Period	
Site Name	Tanbark Flat	Number of samples	52
		Valid Samples	48
Site ID	CA42	with precipitation	26
State	CA	with full chemistry**	24
County	Los Angeles	without chemistry	2
Operating Agency	USFS-Riverside Forest Fire Lab.	without precipitation	22
Sponsoring Agency	USFS	Invalid Samples	4
		with precipitation	4
		missing precipitation data	0
Latitude	34:12:26		
Longitude	117:45:40		
Elevation	853 m		

Summary Period Information					
	<u>Annual</u>	<u>Winter</u>	<u>Spring</u>	<u>Summer</u>	<u>Fall</u>
First summary period day	12/30/1997	12/02/1997	03/03/1998	06/02/1998	09/01/1998
Last summary period day	12/29/1998	02/24/1998	06/02/1998	09/01/1998	12/01/1998
Summary period duration	364	91	91	91	91
Number of samples	52	13	13	13	13
Measured precipitation (cm)	110.7	63.7	48.5	1.5	3.4
Valid samples with full chemistry**	24	7	9	4	4
Valid field pH measurements	21	7	9	3	2

NADP/NTN Completeness Criteria					
	<u>Annual</u>	<u>Winter</u>	<u>Spring</u>	<u>Summer</u>	<u>Fall</u>
1.Summary period with valid samples (%)	94.2	84.6	100.0	84.6	84.6
2.Summary period with precip coverage (%)	100.0	100.0	100.0	100.0	100.0
3.Measured precipitation with valid samples (%)	93.0	88.2	100.0	95.0	97.0
4.Collector efficiency (%)	96.6	99.8	93.4	97.0	103.4
Precip with full chemistry and valid field pH (%)	92.5	88.2	100.0	80.0	85.7

* = Data do not meet NADP/NTN Completeness Criteria for this period.

** = Valid samples for which all Laboratory Chemical measurements were made (The ONLY samples described by the percentile distributions in the Statistical Summary of Precipitation Chemistry for Valid Samples).

*** = Measured precipitation for sample periods during which precipitation occurred and for which complete valid laboratory chemistry data are available

**National Atmospheric Deposition Program/National Trends Network
1998 Annual & Seasonal Data Summary for Site CA42**

Page 2: Statistical Summary of Precipitation Chemistry for Valid Samples

Precipitation-Weighted Mean Concentrations												
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	mg/L											
Annual	0.06	0.047	0.018	0.373	0.20	0.92	0.65	0.43	8.71E-03	9.51E-03	5.06	5.02
Winter	0.03	0.034	0.009	0.286	0.07	0.41	0.49	0.21	5.79E-03	7.40E-03	5.24	5.13
Spring	0.09	0.058	0.025	0.455	0.28	1.12	0.79	0.61	9.18E-03	9.25E-03	5.04	5.03
Summer	0.28	0.059	0.090	0.272	1.35	8.44	0.53	2.06	7.14E-02	7.50E-02	4.15	4.13
Fall	0.04	0.034	0.014	0.280	0.16	0.63	0.48	0.26	5.81E-03	6.25E-03	5.24	5.20

Deposition												
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	kg/ha											
Annual	0.69	0.520	0.199	4.128	2.22	10.14	7.16	4.78	9.64E-02	1.05E-01	—	—
Winter	0.18	0.217	0.057	1.823	0.47	2.61	3.14	1.36	3.69E-02	4.71E-02	—	—
Spring	0.43	0.281	0.121	2.206	1.38	5.43	3.81	2.96	4.45E-02	4.48E-02	—	—
Summer	0.04	0.009	0.014	0.041	0.21	1.29	0.08	0.31	1.09E-02	1.14E-02	—	—
Fall	0.01	0.011	0.005	0.095	0.06	0.21	0.16	0.09	1.96E-03	2.11E-03	—	—

Weekly Sample Concentrations												
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	mg/L											
Minimum value	0.01	0.006	0.003	0.014	0.02	0.22	0.04	0.10	1.70E-03	2.63E-03	3.92	3.90
Percentile 10	0.01	0.006	0.003	0.042	0.04	0.41	0.06	0.11	3.06E-03	4.67E-03	4.22	4.19
Percentile 25	0.04	0.013	0.007	0.077	0.10	0.65	0.15	0.37	5.89E-03	6.38E-03	4.52	4.53
Percentile 50	0.09	0.042	0.024	0.269	0.34	1.08	0.50	0.50	8.92E-03	1.00E-02	5.05	5.00
Percentile 75	0.18	0.090	0.041	0.719	0.92	4.90	1.17	1.13	3.06E-02	2.97E-02	5.23	5.20
Percentile 90	0.41	0.115	0.116	0.882	1.18	6.41	1.48	2.52	6.13E-02	6.42E-02	5.55	5.33
Maximum value	0.50	0.138	0.455	0.906	1.88	12.88	1.59	2.99	1.20E-01	1.26E-01	5.77	5.58
Arithmetic mean	0.13	0.054	0.046	0.380	0.51	2.82	0.64	0.89	2.26E-02	2.27E-02	4.65	4.64
Arith. std dev	0.14	0.042	0.092	0.327	0.49	3.05	0.53	0.84	2.80E-02	2.90E-02	—	—
Below detection	0	0	3	0	1	0	0	0	—	—	—	—

Other Parameters						Annual and Seasonal Equivalence Ratios			
	Measured Precipitation*** cm	Conduc- tivity uS/cm	Equivalence Ratios				SO4 NO3	SO4+NO3 H	Cation Anion
			SO4	SO4+NO3	Cation				
			NO3	H	Anion				
Minimum value	0.03	3.0	0.20	1.16	0.61	Annual	0.61	2.73	1.04
Percentile 10	0.17	4.2	0.23	1.49	0.91	Winter	0.67	1.91	1.07
Percentile 25	0.48	6.8	0.26	1.99	0.96	Spring	0.70	3.35	1.03
Percentile 50	1.45	11.1	0.50	2.67	1.02	Summer	0.31	2.50	0.92
Percentile 75	5.96	27.8	0.64	4.17	1.05	Fall	0.52	2.67	1.11
Percentile 90	14.87	45.2	0.96	10.62	1.20				
Maximum value	21.23	77.7	1.78	16.22	1.25				

Please see page 1 for footnotes.

National Atmospheric Deposition Program/National Trends Network

1999 Annual & Seasonal Data Summary for Site CA42

Page 1: Summary of Sample Validity and Completeness Criteria

(Printed 08/29/2000)

Site Identification		Sample Validity for Annual Period	
Site Name	Tanbark Flat	Number of samples	52
Site ID	CA42	Valid Samples	48
State	CA	with precipitation	14
County	Los Angeles	with full chemistry**	14
Operating Agency	USFS-Riverside Forest Fire Lab.	without chemistry	0
Sponsoring Agency	USFS	without precipitation	34
Latitude	34:12:26	Invalid Samples	4
Longitude	117:45:40	with precipitation	4
Elevation	853 m	missing precipitation data	0

Summary Period Information					
	<u>Annual</u>	<u>Winter</u>	<u>Spring*</u>	<u>Summer</u>	<u>Fall</u>
First summary period day	12/29/1998	12/01/1998	03/02/1999	06/01/1999	08/31/1999
Last summary period day	12/28/1999	02/23/1999	06/01/1999	08/31/1999	11/30/1999
Summary period duration	364	91	91	91	91
Number of samples	52	13	13	13	13
Measured precipitation (cm)	29.2	13.3	13.5	2.6	1.3
Valid samples with full chemistry**	14	6	6	2	2
Valid field pH measurements	10	6	4	1	1

NADP/NTN Completeness Criteria					
	<u>Annual</u>	<u>Winter</u>	<u>Spring*</u>	<u>Summer</u>	<u>Fall</u>
1.Summary period with valid samples (%)	92.0	100.0	68.1	100.0	100.0
2.Summary period with precip coverage (%)	100.0	100.0	100.0	100.0	100.0
3.Measured precipitation with valid samples (%)	88.4	100.0	74.8	100.0	100.0
4.Collector efficiency (%)	90.2	90.3	93.4	85.3	84.2
Precip with full chemistry and valid field pH (%)	65.8	100.0	27.0	97.1	94.1

* = Data do not meet NADP/NTN Completeness Criteria for this period.

** = Valid samples for which all Laboratory Chemical measurements were made (The ONLY samples described by the percentile distributions in the Statistical Summary of Precipitation Chemistry for Valid Samples).

*** = Measured precipitation for sample periods during which precipitation occurred and for which complete valid laboratory chemistry data are available

**National Atmospheric Deposition Program/National Trends Network
1999 Annual & Seasonal Data Summary for Site CA42**

Page 2: Statistical Summary of Precipitation Chemistry for Valid Samples

Precipitation-Weighted Mean Concentrations													
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)	
	mg/L												
Annual	0.09	0.040	0.026	0.274	0.35	1.33	0.46	0.57	8.47E-03	1.05E-02	5.07	4.98	
Winter	0.05	0.041	0.029	0.293	0.41	1.75	0.50	0.54	1.26E-02	1.35E-02	4.90	4.87	
Spring*	0.14	0.048	0.020	0.349	0.34	1.34	0.55	0.54	5.50E-03	9.27E-03	5.26	5.03	
Summer	0.14	0.034	0.047	0.177	0.45	1.67	0.32	1.18	1.79E-02	1.45E-02	4.75	4.84	
Fall	0.08	0.012	0.011	0.093	0.08	0.87	0.13	0.36	8.36E-03	1.48E-02	5.08	4.83	
Deposition													
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)	
	kg/ha												
Annual	0.27	0.117	0.076	0.800	1.01	3.89	1.33	1.66	2.47E-02	3.06E-02	--	--	
Winter	0.07	0.054	0.038	0.388	0.54	2.32	0.66	0.72	1.68E-02	1.79E-02	--	--	
Spring*	0.19	0.065	0.027	0.470	0.45	1.80	0.74	0.73	7.40E-03	1.25E-02	--	--	
Summer	0.04	0.009	0.012	0.046	0.12	0.44	0.08	0.31	4.67E-03	3.78E-03	--	--	
Fall	0.01	0.002	0.001	0.012	0.01	0.11	0.02	0.05	1.08E-03	1.92E-03	--	--	
Weekly Sample Concentrations													
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)	
	mg/L												
Minimum value	0.02	0.003	0.003	0.016	0.06	0.47	0.05	0.14	8.51E-04	2.57E-03	4.42	4.36	
Percentile 10	0.02	0.006	0.003	0.023	0.09	0.47	0.05	0.25	1.54E-03	2.62E-03	4.43	4.36	
Percentile 25	0.04	0.019	0.010	0.131	0.23	0.85	0.12	0.37	4.10E-03	3.16E-03	4.71	4.83	
Percentile 50	0.09	0.036	0.021	0.219	0.36	1.34	0.30	0.52	7.41E-03	9.12E-03	5.13	5.04	
Percentile 75	0.79	0.116	0.087	0.539	0.82	7.50	0.89	1.60	1.95E-02	1.48E-02	5.39	5.50	
Percentile 90	1.37	0.403	0.218	3.334	2.89	12.78	4.94	3.96	3.68E-02	4.33E-02	5.86	5.58	
Maximum value	1.75	0.479	0.255	3.858	2.98	13.24	6.15	4.74	3.80E-02	4.37E-02	6.07	5.59	
Arithmetic mean	0.38	0.100	0.059	0.684	0.77	3.86	1.03	1.18	1.25E-02	1.40E-02	4.90	4.85	
Arith. std dev	0.52	0.146	0.079	1.160	0.96	4.55	1.76	1.41	1.22E-02	1.48E-02	--	--	
Below detection	0	0	0	0	0	0	0	0	--	--	--	--	
Other Parameters							Annual and Seasonal Equivalence Ratios						
	Measured Precipitation*** cm	Conduc- tivity uS/cm	Equivalence Ratios				SO4 NO3	SO4+NO3 H	Cation Anion		SO4 NO3	SO4+NO3 H	Cation Anion
			SO4	SO4+NO3	Cation								
			NO3	H	Anion								
Minimum value	0.05	4.6	0.07	1.67	0.79	Annual	0.55	3.93	1.04				
Percentile 10	0.06	4.9	0.14	1.85	0.84	Winter	0.40	3.13	1.02				
Percentile 25	0.34	6.4	0.29	2.41	0.93	Spring*	0.53	5.98	1.05				
Percentile 50	1.37	8.6	0.53	5.40	1.03	Summer	0.91	2.88	1.01				
Percentile 75	3.02	30.6	0.73	12.60	1.10	Fall	0.54	2.58	0.87				
Percentile 90	5.24	64.7	1.04	40.53	1.20								
Maximum value	6.38	76.0	1.10	43.28	1.25								

Please see page 1 for footnotes.

National Atmospheric Deposition Program/National Trends Network
2000 Annual & Seasonal Data Summary for Site CA42
Part 1: Summary of Sample Validity and Completeness Criteria
(Printed 09/14/2001)

Site Identification		Sample Validity for Annual Period	
Site Name	Tanbark Flat	Number of samples	53
Site ID	CA42	Valid Samples	51
State	CA	with precipitation	21
County	Los Angeles	with full chemistry**	17
Operating Agency	USDA-Forest Service	without chemistry	4
Sponsoring Agency	USDA-Forest Service-Riverside Forest Fire Lab	without precipitation	30
Latitude	34:12:26	Invalid Samples	2
Longitude	117:45:40	with precipitation	2
Elevation	853 m	missing precipitation data	0

Summary Period Information					
	<u>Annual</u>	<u>Winter</u>	<u>Spring</u>	<u>Summer*</u>	<u>Fall</u>
First summary period day	12/28/1999	11/30/1999	03/01/2000	05/30/2000	08/29/2000
Last summary period day	01/03/2001	03/01/2000	05/30/2000	08/29/2000	11/28/2000
Summary period duration	372	92	90	91	91
Number of samples	53	13	13	13	13
Measured precipitation (cm)	58.4	32.8	19.8	0.0	5.8
Valid samples with full chemistry**	17	7	6	0	4
Valid field pH measurements	14	6	5	0	3

NADP/NTN Completeness Criteria					
	<u>Annual</u>	<u>Winter</u>	<u>Spring</u>	<u>Summer*</u>	<u>Fall</u>
1.Summary period with valid samples (%)	96	100	100	100	92
2.Summary period with precip coverage (%)	100	100	100	100	100
3.Measured precipitation with valid samples (%)	100	100	100	100	97
4.Collector efficiency (%)	86	88	83	--	82
Precip with full chemistry and valid field pH (%)	98	100	98	0	95

* = Data do not meet NADP/NTN Completeness Criteria for this period.

** = Valid samples for which all Laboratory Chemical measurements were made (The ONLY samples described by the percentile distributions in the Statistical Summary of Precipitation Chemistry for Valid Samples).

*** = Measured precipitation for sample periods during which precipitation occurred and for which complete valid laboratory chemistry data are available

**National Atmospheric Deposition Program/National Trends Network
2000 Annual & Seasonal Data Summary for Site CA42**

Part 2: Statistical Summary of Precipitation Chemistry for Valid Samples

Precipitation-Weighted Mean Concentrations												
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	mg/L											
Annual	0.04	0.023	0.010	0.201	0.24	0.80	0.33	0.36	6.31E-03	6.11E-03	5.20	5.21
Winter	0.02	0.012	0.006	0.110	0.18	0.44	0.18	0.24	4.09E-03	3.97E-03	5.39	5.40
Spring	0.06	0.039	0.015	0.334	0.31	1.28	0.55	0.52	9.38E-03	9.91E-03	5.03	5.00
Summer*	--	--	--	--	--	--	--	--	--	--	--	--
Fall	0.07	0.030	0.016	0.263	0.30	1.24	0.41	0.52	8.51E-03	5.48E-03	5.07	5.26

Deposition												
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	kg/ha											
Annual	0.22	0.134	0.058	1.173	1.39	4.68	1.93	2.11	3.68E-02	3.57E-02	--	--
Winter	0.06	0.039	0.020	0.360	0.60	1.44	0.60	0.79	1.34E-02	1.30E-02	--	--
Spring	0.12	0.077	0.030	0.660	0.61	2.54	1.09	1.02	1.85E-02	1.96E-02	--	--
Summer*	--	--	--	--	--	--	--	--	--	--	--	--
Fall	0.04	0.017	0.009	0.152	0.17	0.71	0.23	0.30	4.91E-03	3.16E-03	--	--

Weekly Sample Concentrations												
	Ca	Mg	K	Na	NH4	NO3	Cl	SO4	H(lab)	H(fld)	pH(lab)	pH(fld)
	mg/L											
Minimum value	0.01	0.003	0.003	0.010	0.09	0.24	0.02	0.13	1.38E-03	1.32E-03	3.94	3.95
Percentile 10	0.01	0.007	0.003	0.046	0.10	0.38	0.08	0.15	1.46E-03	1.73E-03	4.00	4.26
Percentile 25	0.02	0.014	0.007	0.120	0.18	0.50	0.23	0.28	3.01E-03	3.95E-03	4.41	4.78
Percentile 50	0.05	0.032	0.012	0.214	0.27	1.47	0.35	0.56	1.07E-02	7.05E-03	4.97	5.15
Percentile 75	0.30	0.086	0.073	0.696	1.13	3.28	1.02	2.38	4.04E-02	1.64E-02	5.54	5.41
Percentile 90	0.43	0.295	0.112	2.540	2.06	12.19	3.81	4.89	1.01E-01	6.99E-02	5.84	5.78
Maximum value	0.44	0.350	0.130	2.860	2.46	13.77	4.16	5.00	1.15E-01	1.12E-01	5.86	5.88
Arithmetic mean										--		--
Arith. std dev											--	--
Below detection									--	--	--	--

Other Parameters						Annual and Seasonal Equivalence Ratios			
	Measured Precipitation*** cm	Conduc- tivity uS/cm	Equivalence Ratios				SO4 NO3	SO4+NO3 H	Cation Anion
			SO4	SO4+NO3	Cation				
			NO3	H	Anion				
Minimum value	1.27	3.0	0.33	1.68	0.84	Annual	0.58	3.25	1.08
Percentile 10	1.27	4.0	0.35	1.75	0.86	Winter	0.71	2.96	1.22
Percentile 25	3.43	4.9	0.44	2.39	0.93	Spring	0.52	3.35	1.02
Percentile 50	11.94	10.6	0.56	2.98	1.00	Summer*	--	--	--
Percentile 75	57.66	37.1	0.85	4.86	1.12	Fall	0.54	3.62	1.01
Percentile 90	111.56	78.8	2.56	17.11	1.23				
Maximum value	156.46	84.6	2.61	53.79	1.50				

Please see page 1 for footnotes.

Figure 39-1

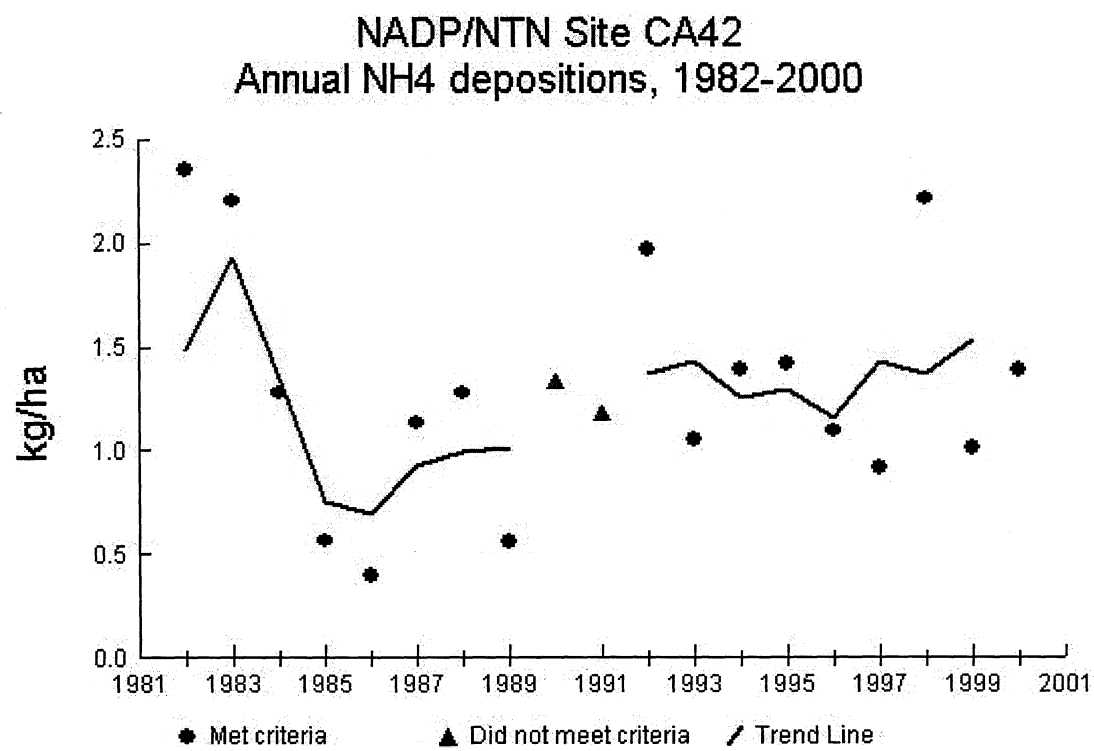
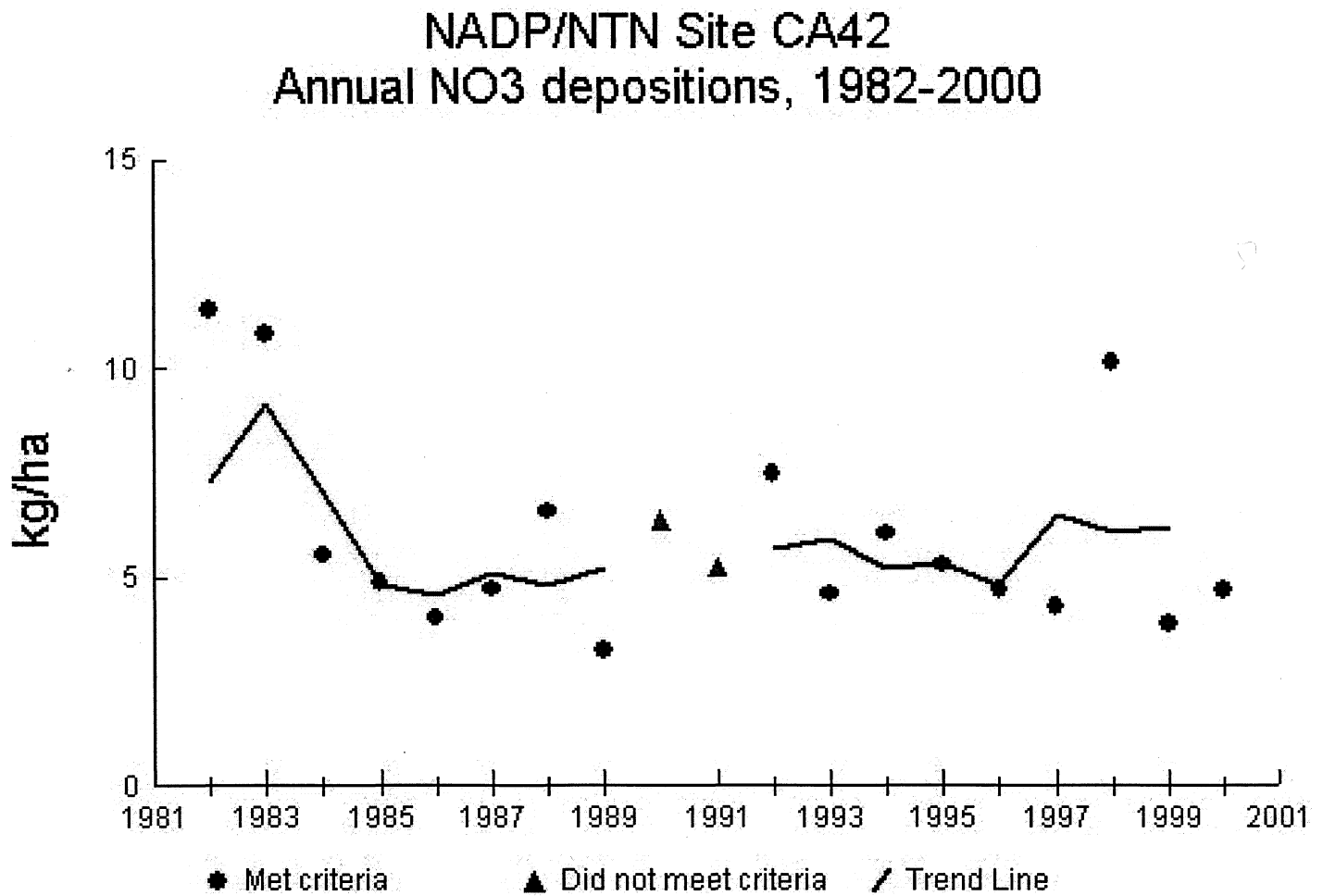
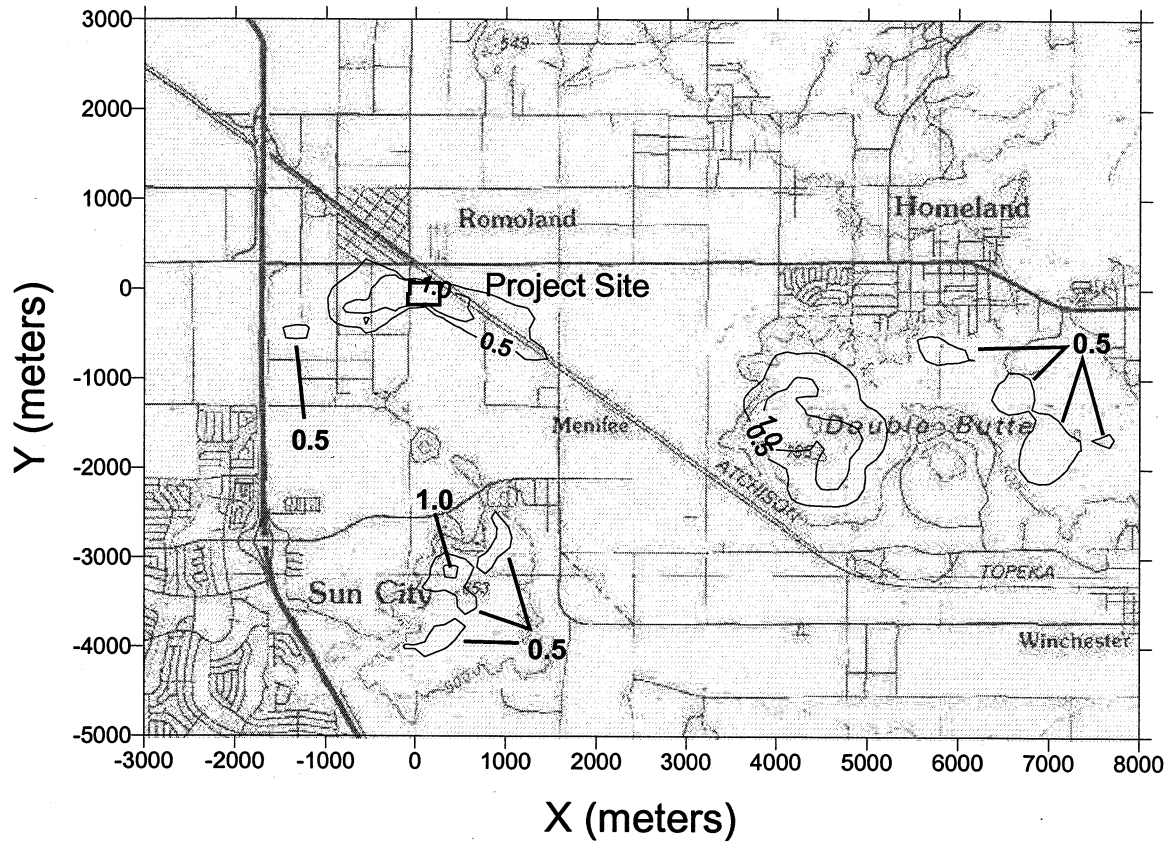


Figure 39-2



Bio Attachment 1
Nitrogen Deposition Isopleths

IEEC Nitrogen Deposition - kg N/(ha-yr)



Bio Attachment 2

Effects of Acid Deposition on Man-Made Materials

Effect of Acid Deposition on Man-Made Materials

Damage to galvanized steel due to atmospheric acidity in the South Coast Air Basin of California (SoCAB) was found to be much less than that reported in the eastern United States and Europe. However, damage to aluminum exceeded that found in three other U.S. cities. Also, damage rates in the SoCAB were lower in the winter than in the summer, the reverse of the pattern in the eastern United States and Europe. Polluted air in California contains much higher levels of nitric acid, and levels of sulfuric acid and acidic sulfates that are lower than are found in other part of the United States or Europe. Past studies have shown that damage to metals is correlated with sulfur dioxide concentrations. These results suggest that emissions of nitrogen oxides may also be a factor in corrosion damage. This study was performed by Valley Research Corporation; San Jose State University; Combustion Engineering and University of Southern California; Versar, Inc. and Opinion Research Corporation; and the University of Southern California.

Background: Air pollution increases the corrosion and/or erosion of many types of manufactured and natural materials. The Air Resources Board is directed by the Kapiloff Acid Deposition Act and the Atmospheric Acidity Protection Act to quantify the economic impact of the damage to materials caused by atmospheric acidity. Although the National Acid Precipitation Assessment Program (NAPAP) has completed a nationwide assessment of the impact of acid deposition on materials, NAPAP's research is not applicable to California. Air pollution in California is typically much higher in nitric acid and lower in sulfuric acid and acidic sulfates than air pollution in other parts of the United States or in Europe. As part of the ARB's acid deposition research and monitoring program, four projects were funded to assess materials damage from acid deposition in the South Coast Air Basin (SoCAB).

Methods: A comprehensive inventory of economically significant materials susceptible to damage by acidic deposition was developed. Galvanized steel, nickel, aluminum, two types of flat latex exterior house paint, nylon fabric, polyethylene, and concrete were selected for field and controlled laboratory exposure tests. Corrosion rates were determined for galvanized steel, nickel, aluminum, two types of flat latex exterior house paint, and nylon fabric. In addition, the economic costs associated with acid deposition damage to painted wood surfaces on single family homes in the SoCAB were derived from a case study.

Results: The primary findings of these studies include:

- The relationships between acidic pollutant levels and weight loss for galvanized steel, nickel and aluminum were quantified.
- Corrosion rates for galvanized steel (used as the benchmark material in most atmospheric exposure tests) were very low and were similar to rates observed at clean rural sites. Corrosion rates for nickel were also very low, but rates for aluminum were higher than those found in three other U.S. cities.
- Corrosion rates for galvanized steel, nickel, and aluminum were higher from May to September. Corrosion correlates with photochemical smog levels, which are highest during the summer

months in the SoCAB.

- Total exposed surface material on structures in the Basin was estimated to be 37.4 billion square feet. Single family residences represent about 55 percent of the total surfaces. Wood is the most prevalent painted surface on single family residences (47 percent), followed by stucco (43 percent), aluminum (5 percent), and concrete (2 percent).
- One of the studies estimated that a ten-percent reduction in ambient nitrogen dioxide concentrations (considered a surrogate for acidity) in the SoCAB would reduce annual maintenance costs for painted wood surfaces on single family homes by \$0.7 to \$3.6 million (1988 dollars).

The results generally indicate that the potential for economic losses from damage to materials due to atmospheric acidity may not be as significant as initially estimated.

- Significance and Application:** These studies provide valuable information on the effects of acid deposition on materials commonly used outdoors in the SoCAB. Information gathered through these studies will be used by the ARB in its assessment of the welfare effects of acid deposition in California.
- Related Projects:** The ARB also funded this related study: *Investigation of the Effects of Atmospheric Acidity Upon Economically Significant Materials*, ARB contract no. A932-113.

This research was conducted by several different contractors (ARB contract numbers in parentheses): Valley Research Corporation and San Jose State University (A6-079-32); Combustion Engineering and University of Southern California (A4-110-32 and A5-137-32); Versar, Inc. and Opinion Research Corporation (A732-062); and the University of Southern California (A6-079-32). Comments or questions can be directed to the contract manager, Marla Mueller, by mail, FAX (916) 322-4357, phone (916) 323-1529, or e-mail: mmueller@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

National Technical Information Service

5285 Port Royal Rd
Springfield VA 22161

NTIS numbers: various (To ascertain the NTIS numbers of the different contract reports, contact us. Specify ARB contract number and contractor.)

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Preliminary Findings of the California Acid Deposition Monitoring Program

This study was initiated to build on the early acid deposition work developed under the Kapiloff Acid Deposition Act of 1982. The specific objective was to design a monitoring network to measure parameters needed to estimate the dry deposition flux of acidic gases and particles. Development of methods for measuring dry deposition resulted in establishment of the California Dry Deposition Monitoring Network, which consists of ten sites located from Gasquet in northern California to Long Beach in southern California. This study was performed by the Desert Research Institute, University of Nevada, Reno.

Background: The Kapiloff Acid Deposition Act of 1982 required the Air Resources Board to determine the regions in California where acid deposition occurs, or might be expected to occur, in amounts that could be adverse to the environment, the economy, or the public health. The California Acid Deposition Monitoring Program (CADMP) was established to meet this requirement. Acid deposition can occur in rainfall or snow, or in dry form as acidic gases and particles deposited from the atmosphere to surfaces. In part because of the lack of summer rainfall in California, early estimates indicated that dry deposition was relatively more important in California than in the eastern United States. Wet deposition, such as occurs in rain and snow, is relatively straightforward to monitor; dry deposition is more difficult. The initial California Acid Deposition Monitoring Network monitored deposition from rain and snow throughout the state, and efforts were begun to determine how to monitor fog and dry deposition of acidic gases and particles. This study describes the network and the measurements made in the first 1½ years of operation.

Methods: A complete list of sites set up for this network and their characteristics is shown in Table 1.

Table 1

Site	<input type="checkbox"/>	Site Type	<input type="checkbox"/>	Surrounding Terrain	<input type="checkbox"/>	Elevation, meters (feet)
Gasquet	<input type="checkbox"/>	Rural	<input type="checkbox"/>	Forest, rolling	<input type="checkbox"/>	120 (394)
Sacramento	<input type="checkbox"/>	Urban	<input type="checkbox"/>	Low buildings, trees	<input type="checkbox"/>	3 (10)
Fremont	<input type="checkbox"/>	Urban	<input type="checkbox"/>	Low buildings	<input type="checkbox"/>	16 (53)
Yosemite NP	<input type="checkbox"/>	Rural	<input type="checkbox"/>	Rugged, exposed rock	<input type="checkbox"/>	1609 (5278)
Sequoia NP	<input type="checkbox"/>	Rural	<input type="checkbox"/>	Rugged, trees & rock	<input type="checkbox"/>	1914 (6278)
Bakersfield	<input type="checkbox"/>	Urban	<input type="checkbox"/>	Low building	<input type="checkbox"/>	120 (394)
Santa Barbara	<input type="checkbox"/>	Coastal	<input type="checkbox"/>	Residential	<input type="checkbox"/>	20 (66)
Los Angeles	<input type="checkbox"/>	Urban	<input type="checkbox"/>	Medium buildings	<input type="checkbox"/>	27 (88)
Azusa	<input type="checkbox"/>	Urban	<input type="checkbox"/>	Low buildings	<input type="checkbox"/>	90 (295)
Long Beach	<input type="checkbox"/>	Urban	<input type="checkbox"/>	Medium buildings	<input type="checkbox"/>	187 (613)

The method used to monitor dry deposition estimates acidic fluxes by measuring the airborne concentrations of acidic species, along with specific meteorological parameters. A model then calculates a "deposition velocity" for each species from the meteorological parameters, and combines it with the concentration to compute the flux.

Parameters monitored for dry deposition in the CADMP include hourly average values for ozone, wind speed, wind direction, atmospheric stability, temperature, dew point, time of wetness, and solar radiation. Daytime (6:01 a.m. to 6:00 p.m. PST) and nighttime (6:01 p.m. to 6:00 a.m. PST) measurements are taken every sixth day for sulfur dioxide, ammonia, nitrogen dioxide, and nitric acid gases. Mass, sulfate, nitrate, chloride, ammonium, sodium, magnesium, potassium, and calcium ion measurements are made on filter samples of particles in the PM_{2.5} and PM₁₀ size ranges. PM_{2.5} and PM₁₀ designate particles 2.5 and 10 microns (μm) or less in diameter, respectively. These particles are important because they can pass into the human respiratory system.

Results:

This study summarizes the first one and a half years of network data. Monitoring is ongoing, however, and updated results are continually examined. Some preliminary results indicate that the highest nitric acid concentrations during the summer daytime are in Azusa, downwind of Los Angeles. Los Angeles, Long Beach, and Bakersfield also have elevated concentrations relative to the other sites. As expected, summer nighttime concentrations of nitric acid drop to near zero. Summer sulfur dioxide concentrations are highest in Bakersfield and the Los Angeles basin. In Bakersfield, summer nighttime sulfur dioxide is nearly as high as during the daytime. Summer ammonia concentrations are high during the day in the central valley sites of Sacramento and Bakersfield, and at the Los Angeles and Azusa sites. At Sacramento and Bakersfield the summer concentrations remain high at night, but drop slightly at the Los Angeles basin sites.

In winter, the nitric acid concentrations are much lower than during the photochemically active summer period. Daytime and nighttime particulate nitrate concentrations are high, however, especially at the urban sites.

The PM_{2.5} size range contains 60-100 percent of the sulfate, nitrate, and ammonium particles. These particles are generally formed in the atmosphere by photochemical reactions. For the geologically related materials (mostly soil dust), including magnesium, potassium, and calcium, more than half is found in the size range between 2.5 and 10 μm .

The daytime average concentrations of all particulate species are similar to the nighttime averages. The gaseous species show wide variation, however, between daytime and nighttime. Nitric acid decreases by a factor of 10 from day to night. The daytime sulfur dioxide concentration is larger than the nighttime concentration at most sites, and is more than twice the nighttime average at Fremont, Santa Barbara, Long Beach, Los Angeles,

and Azusa. On the other hand, average nitrogen dioxide concentrations are higher at night, by almost a factor of two, at Gasquet and Bakersfield, and are nearly equal at Fremont, Long Beach, Los Angeles, and Azusa.

Significance and Application: Dry deposition is important in California because the prime photochemical period that produces much of atmospheric acidity coincides with the dry summer months. This project established the first California network to monitor the acidic concentrations and meteorological parameters needed to estimate deposition fluxes throughout the state. Although the project has already begun to produce useful information, its primary benefit will be realized after it has been in operation for several years. This will enable the ARB to examine trends of deposition and atmospheric acidity in relation to emissions of regulated pollutants in the state.

Related Projects: Several ARB-funded projects have been initiated to examine the data produced by the CADMP dry deposition network. In one study, estimates of California regional acid deposition fluxes are being calculated using CADMP data. In another, source-receptor relationships for atmospheric acidity and acid deposition are being evaluated.

This research was conducted under contract with with Desert Research Institute, University of Nevada, Reno (ARB contract no. A6-076-32). Comments or questions can be directed to the contract manager, Nehzat Motallebi, by mail, FAX (916) 322-4357, phone (916) 324-1744, or e-mail: nmotalle@arb.ca.gov . For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:
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<u>National Technical Information Service</u> 5285 Port Royal Rd Springfield VA 22161 Request NTIS No. PB92-167030

Title: <i>Measurements of Dry Deposition Parameters for the California Acid Deposition Monitoring Program</i>

Authors: John G. Watson, Judith C. Chow

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Application of Models to Predict Acidity Changes in Alpine Watersheds in the Sierra Nevada

The objective of this project was to determine whether the Alpine Lake Forecaster could be applied to four watersheds in the Sierra Nevada for data collected between 1986 and 1988. The analysis showed that the Forecaster can be applied to three of the four watersheds. It is also suggested that one of the coefficients in the model can be used to assess the sensitivity of other watersheds in the Sierra to acidic deposition. The results of a multivariate mixing model indicate that two soil environments - the bench meadow and the inlet meadow - may explain most of the observed variation in stream chemistry. This study was performed by the U.S. Geological Survey.

Background: Studies conducted under the Kapiloff Acid Deposition Program showed that there was a significant decrease in the pH and alkalinity during spring snowmelt at Emerald Lake [altitude 2800 m (9,184 ft)] in the Sierra Nevada. To determine whether changes in deposition could cause acidification during snowmelt, a computer simulation model was developed to predict the alkalinity of Emerald Lake and its inlet streams. This model, the Alpine Lake Forecaster, is a coupled hydrologic and chemical model. The chemical formulation includes mineral weathering, the carbonate buffering system, and a simplified representation of the nitrogen cycle.

At the start of the Atmospheric Acidity Protection Program in 1989, studies were planned to regionalize the findings of its predecessor, the Kapiloff Program. Toward this end, this project was proposed to determine whether the Forecaster could be applied to four other watersheds in the Sierra Nevada: Pear [2,904 m (9,528 ft)], Topaz [3,219 m (10,561 ft)], Crystal [2,951 m (9,682 ft)], and Ruby [3,426 m (11,240 ft)] Lakes. In addition, the project included sensitivity analysis of one of the coefficients in the model and the construction of a multivariate mixing model for Emerald Lake.

Methods: Regression analysis was used to test the applicability of the Forecaster to the four lakes. The intent of this application was to investigate the relevance of the hydrochemical formulation in the Forecaster, which was derived from Emerald Lake data, to the other lake watersheds. Discharge and chemical data used were from work performed under a previous ARB contract.

The multivariate mixing model is based on the premise that streamwater is a mixture of source solutions, which have more extreme concentrations than the stream itself. In this study, samples from the inlets to Emerald Lake and soil solutions from two depths at three sites were analyzed.

Results: The Forecaster was found to be applicable to Ruby and Topaz Lakes, but not to Pear Lake. The results for Crystal Lake indicated that in-lake processes not included in the model may affect water chemistry.

While the Forecaster was found to be applicable to two, and perhaps three, of the lakes, the relationships among model parameters for those lakes are weaker than for those at Emerald Lake, creating more uncertainty in model predictions. In addition, more information is needed to assure that the reaction constant is appropriate.

Sensitivity analysis of the model's stoichiometric coefficient indicates that there is little change in model prediction when this number is decreased from 1.2 to 1.0; but a coefficient of 0.5 or less substantially lowers the alkalinity of the streamwater. The authors suggest that this coefficient can be used to assess the sensitivity to acidification of other watersheds in the Sierra that are hydrologically similar to Emerald Lake.

Analysis by the multivariate mixing model showed that deep and shallow soil solutions were similar and that the concentrations of the soil solutions from the inlet and from bench meadows may explain the large variation in streamwater chemistry. In addition, the model showed that there is a source of calcium to the surface water that has not yet been identified.

Significance and Application: For some lakes in the Sierra Nevada the Alpine Lake Forecaster will be useful in predicting short-term changes in alkalinity during spring snowmelt. Given a range of deposition rates, the model can also be used to predict the likelihood of lake acidification.

Related Projects: In 1989 Board researchers used the Episodic Event Model to assess the regional effect of changes in the deposition of hydrogen ion on short term reductions in alkalinity in lakes in the Sierra.

ARB projects in 1993 and 1994 intensively sampled nine lakes during spring snowmelt to determine the frequency and severity of acidic episodes.

This research was conducted under contract with U.S. Geological Survey (ARB Contract No: A932-076). Comments or questions can be directed to the contract manager, Steve Brown, by mail, FAX (916) 322-4357, phone (916) 323-1526, or e-mail: sbrown@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

U.S. Geological Survey
Books and Open-File Reports Section
Box 25425, Federal Center
Denver, CO 80225
Request Water Resources Investigation Report 93-4030

Title: *Application of a Hydrochemical Model and a Multivariate Soil-Solution Mixing Model to Alpine Watersheds in the Sierra Nevada, California*

Author(s): Richard P. Hooper and Norman E. Peters

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Effects of Ozone and Acidic Deposition on Gas Exchange Responses in Ponderosa Pine

In California, species of pine that are sensitive to air pollution are exposed to harmful levels of ozone and to elevated levels of nitrogen-derived pollutants in acidic deposition. Both of these pollutants can disrupt physiological processes, such as gas exchange by leaves. The objectives of the companion studies on which this Research Note is based were to characterize the effects of ozone, in combination with acidic deposition, on a suite of growth and physiological responses in mature branches and seedlings of ponderosa pine grown under conditions representative of north central California. Exposure to twice-ambient ozone caused moderate reductions in photosynthesis and stomatal conductance in seedlings and mature branches. Exposure to acidic rain had no consistent impact. The results indicate that exposure to elevated levels of ozone inhibits pine tree gas exchange rates throughout the growing season. After several years of exposure, this decrease in gas exchange rates could diminish the ecological and economic value of forest resources. While acid rain alone had no effect after one year of exposure, its long-term effect, in combination with ozone, is not well characterized. The studies were performed by the University of California, Berkeley, and the U.S.D.A. Forest Service.

Background: In the 1960s, field surveys in the San Bernardino mountains documented the presence of pine trees with varying degrees of ozone-caused needle injury. Other researchers found that gas exchange processes, stomatal conductance, and photosynthesis, were depressed in ozone-injured pine needles. In the 1980s, field surveys in the Sierra Nevada found widespread ozone-caused needle injury on Jeffrey and ponderosa pine in Sequoia and Kings Canyon National Parks. These findings suggest that ambient ozone may also be affecting gas exchange processes in pines in the Sierra Nevada.

In forests, trees range in age from very young seedlings (<5 years old) to mature trees (>70 years old). To date, studies on the effects of air pollution on forest species have focused on seedling responses, largely because of the difficulty in exposing mature trees to controlled atmospheres. In most cases, the effects of air pollutants on older trees have been assessed by extrapolating results obtained on seedlings, in consideration of known structural, physiological, and microclimatic differences. Few studies, if any, have collected concurrent, direct measurements of plant responses in trees of different ages, and measurements of this kind are needed to determine whether young and old trees are similarly affected by ambient air pollutants.

Methods: Ponderosa pine (*Pinus ponderosa*) seedlings and mature branches were exposed to ambient ozone or twice-ambient ozone and acidic rain (pH 5.1 or 3.0) for 15 months in branch exposure chambers. Results of these exposures were compared with those from charcoal-filtered (ozone-free) air. Three genotypes of ponderosa pine were examined in this study. The "mature branches" were branches from trees produced by grafting buds from 70-year-old trees onto rootstock seedlings that were grown for over 15 years in a seed production orchard at the U.S.D.A. Forest Service Tree Improvement Center in Chico, California. The trees that were the source of the buds for mature branches were also the source of seed for the

seedlings used in the study. Ozone exposures were applied for 14 hrs per day from September 1991 through December 1992. The acidic rain treatments were applied weekly as 5-cm events from January through May 1992. Acidic gases and particles were measured over a three-day period in summer to quantify acidic depositions during dry periods. Measurements of mid-day photosynthesis and stomatal conductance were made at monthly intervals from February through November 1992, using a portable gas exchange system.

Results:

Daytime 12-hr average ozone concentrations were ~20, ~40, and ~80 ppb in the charcoal-filtered air, ambient ozone, and twice-ambient ozone treatments, respectively. The pH 5.1 acidic rain treatment provided wet-deposited hydrogen ion, nitrogen, and sulfur inputs of 6.6, 25, and 29 meq per square meter, while inputs in the pH 3.0 rain treatment were 128, 18, and 12 times higher, respectively. In July, mean concentrations of nitric acid vapor were 4.4 μg per cubic meter during the day and 1.7 μg per cubic meter at night.

Mid-day gas exchange rates were measured in mature branches and seedlings from February through November 1992. Mean rates of stomatal conductance and photosynthesis, and the effects of ozone, differed as a function of plant life stage (mature branch or seedling) and needle age (current-year or one-year-old). Gas exchange rates were consistently higher in seedlings than in mature branches. In seedlings, mean stomatal conductance and photosynthesis ranged from 0.06 to 0.12 mol per square meter per second and 3.0 to 5.1 $\mu\text{mol CO}_2$ per square meter per second, respectively. In mature branches, corresponding values ranged from 0.05 to 0.09 mol per square meter per second and 3.2 to 4.5 $\mu\text{mol CO}_2$ per square meter per second. In terms of needle age, mean gas exchange rates were higher in current-year (emerged in 1992) than one-year-old needles (emerged in 1991). Differences between needle age classes were more pronounced in seedlings than in mature branches; rates in current-year needles were 40 to 70 percent higher than in one-year-old needles in seedlings and 20 to 40 percent higher in mature branches.

Plants exposed to twice-ambient ozone exhibited consistent decreases in gas exchange rates, but the effects of ambient ozone were very slight. Statistically significant decreases were observed in one-year-old needles of mature branches, which experienced 15 and 20 percent decreases in stomatal conductance and net photosynthesis, respectively, relative to plants exposed to charcoal-filtered air. Decreases of similar magnitude (~15 percent) were observed in one-year-old needles in seedlings, but the differences were not statistically significant. In current-year foliage, decreases in gas exchange caused by twice-ambient ozone levels ranged from 3 to 12 percent. Among genotypes, decreases in gas exchange caused by twice-ambient ozone levels tended to be less pronounced in the clone of intermediate vigor than in the clones of low and high vigor.

Significance and Application: The availability of mature branches and trees with the same genetic background, and extensive facilities for exposing pines to ozone and acidic rain, provided an uncommon opportunity to collect concurrent, direct measurements of gas exchange on trees of different ages. Strictly speaking, although the study did not examine mature whole trees, the branches used in the study are structurally and physiologically similar to branches from mature whole trees. Studying mature branches in conjunction with seedlings enables direct comparisons to be made between tree responses to air pollutants at young and older life stages.

The results of these studies indicate that gas exchange rates in older trees may be more sensitive to ozone-caused decreases than in seedlings. Moreover, one-year-old needles exhibit greater ozone-caused depressions than current-year needles; this is consistent with the cumulative nature of ozone injury to pine tree needles. If air pollution-related decrements in fundamental growth processes are occurring at levels found in forests outside the South Coast Air Basin, improvements in air quality may be needed statewide to prevent the gradual deterioration of our ecological resources.

Related Projects: From 1989 to 1991, the Air Resources Board sponsored a field chamber study to examine the effects of ozone and dry acidic deposition on ponderosa pine seedlings at Shirley Meadow in the southern Sierra Nevada. After two years of exposure, twice-ambient ozone caused reductions in gas exchange rates, foliar starch reserves, and growth of foliage, stems, and roots.

This research was conducted under contract with the University of California, Berkeley, and the U.S.D.A. Forest Service (ARB Contract No.s A132-101 and A132-174). Comments or questions can be directed to the contract manager, Brent Takemoto, by mail, FAX (916) 322-4357, phone (916) 324-2981, or e-mail: btakemo@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

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Request NTIS No. PB94-109063 for the UC Berkeley report. The NTIS number for the USDA Forest Service report is pending.

Reports: *Gas Exchange by Pinus ponderosa in Relation to Atmospheric Pollutant* (A132-101) by J.A. Helms, P.D. Anderson, and J.L.J. Houpis and *Determination of Acidic Gas and Particle Concentrations in Open-Top Field Chambers* (A132-174) by A. Bytnerowicz.

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Data in Support of Direct Free-Radical Measurements in Polluted Urban Air

This study provided measurements of atmospheric compounds related to the formation of ozone and acid deposition to be used in prediction and modeling of atmospheric free-radical concentrations. Comparison of these measurements to those taken for the 1987 Southern California Air Quality Study (SCAQS) reveals a similar photochemical atmosphere. There were also significant differences in the findings of the two studies. For example, no significant contribution of heavy volatile oxygenated organic gases, ubiquitous during the SCAQS, were found. The ratio of carbon monoxide to nitrogen oxides, used to evaluate the accuracy of ARB's emissions inventory, was also significantly lower than that observed during the SCAQS. This study was performed by Unisearch Associates.

Background: The hydroxyl free radical, OH, initiates and propagates atmospheric photochemical reactions that lead to the formation of ozone and essential components of particulate matter (PM₁₀). In 1993, the Environmental Protection Agency funded the first use of a low-pressure laser-induced fluorescence (LIF) spectroscopic device to directly measure free-radical concentrations in Claremont, California. There are very few other reliable methods for accurate direct OH measurement. Therefore, measurements of atmospheric chemicals involved in free-radical processes are critical for OH modeling and estimation. Data from studies such as this one are important for providing information to support direct free-radical measurements and can also be used to determine changes that have occurred since the SCAQS in the atmosphere downwind of the South Coast Air Basin (SoCAB).

Methods: The investigators collected high quality simultaneous measurements of ozone and its precursors, often by more than one method: nitrogen dioxide by chemiluminescence and differential optical absorption spectroscopy (DOAS); hydrogen peroxide by a tunable diode laser absorption spectrometer (TDLAS); formaldehyde by TDLAS and the dinitrophenylhydrazine (DNPH) method; the nitrate radical and nitrous acid by DOAS alone; nitric acid by TDLAS; ozone at the surface by chemiluminescence and the Luminox method; and nitrogen oxide and peroxyacetyl nitrate by chemiluminescence. Carbon monoxide and hydrocarbons through C₁₂ were grab-sampled into canisters and analyzed with a gas chromatograph. Volatile oxygenated organic compounds were collected using the DNPH method -- the same procedure as that used in the SCAQS, with modifications in preparation of the collection tubes. Measurements were nearly continuous for a period of 24 days in August and September 1993.

Results: The quality of the data collected is very good and is comparable to the quality of the 1987 SCAQS data. These high quality data, together with data gathered in other studies on ozone using light detecting and ranging equipment and meteorological data measured using a radar wind profiler and radio acoustic sounding systems, are now available for modeling and estimation of free-radical concentrations. Hydrogen peroxide (H₂O₂) is produced in photochemical reactions that remove OH radicals from the atmosphere; data on H₂O₂ from this study can be used to estimate free radical concentrations. Nitrous acid (HONO) is generally assumed to be a source, through molecular dissociation, of early morning free-radical concentrations (HONO → OH + NO); DOAS measurement of HONO can also be used to estimate free-radical concentrations.

Data from this study can be used to compare the current atmosphere to that determined during SCAQS. Despite an intervening wet weather period, average ozone levels in 1993 were similar to concentrations observed during the SCAQS, but the CO/NO_x ratio is lower. The CO/NO_x decrease may be due to today's more efficient internal combustion engines and their different emissions profile. Investigations to assess changes in the atmosphere will probably focus on the lower CO/NO_x ratio and on two high-ozone episodes that characterized the study period. The composition of volatile oxygenated organic compounds changed substantially between 1987 and 1993. However, this is unexplained by any changes in emissions and may be due to contamination of the DNPH tubes with a higher aldehyde during sample preparation.

Significance and Application: Use of the data obtained in this study to support measurement, estimation, and modeling of free-radical concentrations will improve urban airshed modeling, strengthening the ability of regulators to judge the impact of air pollution control measures. Application of these findings to regional, national, and international air pollution control efforts will lead to more effective approaches to improving air quality.

It is possible that reduction in emissions during the past decade are more easily estimated by observing changes in the ambient composition of photochemically active gases than by measuring ozone levels. Analysis of the data obtained from the current study has helped in the design of a 1995 field study to measure the impact of phase 2 reformulated gasoline on ambient air quality. Improvements in measurement of photochemically active species and a history of their concentrations, provided in this effort, will also have direct application in future studies.

Related Projects: Companion to this study is a work on light detecting and ranging (lidar) above-ground ozone measurements in Davis and Claremont (ARB contract no. 92-328). A study documenting aircraft data from Davis taken at the same time as the lidar data is also available (ARB contract no. 92-330). To evaluate interbasin transport between the SoCAB and the high desert, a study utilizing a two-dimensional ozone lidar, wind profilers, and radio acoustic sounding systems is planned for the summer of 1995. A study using a three-dimensional scanning lidar capable of measuring ozone and nitrogen dioxide is planned for the summer of 1995 to evaluate the spatial variability of pollutants within the volume used by the urban airshed model.

This research was conducted under contract with Unisearch Associates (ARB Contract No. 92-327). Comments or questions can be directed to the contract manager, Ash Lashgari, by mail, FAX (916) 322-4357, phone (916) 323-1506, or e-mail: alashgar@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

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Request NTIS No. PB95-136776

Title: *Atmospheric Free-Radical Measurements Related to Photochemical Oxidants and Acid Deposition*

Author: Gervase I. Mackay

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Atmospheric Deposition to Agricultural Soil

This study was performed to determine whether atmospheric depositions to the nutritional environment of certain of California's commercial crops pose a threat to yield or quality and to what extent depositions might contribute to crop nutrient environments. Aerometric data were used to calculate atmospheric inputs of nitrogen, sulfur, and calcium to crops and to estimate regional-scale deposition rates for selected agricultural production areas. Only nitrogen appeared to provide a potential for excessive nutrient loading to California's agricultural soils. This study was performed by the University of California, Riverside.

Background: Under the Atmospheric Acidity Protection Program, the Air Resources Board is charged with evaluating the effects of acidic deposition on agricultural resources in California. The indirect effects via soil-related reactions are not well documented. Although acidic deposition can beneficially affect plants by supplying nitrogen, sulfur, and other nutrients to foliage and soil, deposition of hydrogen ions and acidifying compounds to the soil may, over the long term, cause an increase in solubility of potentially toxic ions such as aluminum and manganese. In this study, regional-scale deposition rates were determined for nitrogen, sulfur, and calcium, and quantitative analyses were performed to determine whether excess nutrient loading exhibited a potential for adverse effects and whether and to what extent crop nutrient requirements could be supplied by atmospheric deposition.

Methods: Aerometric data from the California Acid Deposition Monitoring Program (CADMP) were used to calculate rates of nitrogen (N), sulfur (S), and calcium (Ca) deposition from precipitation and dry-deposited gases and particles to agricultural lands. The effects of these compounds were evaluated in the context of fertilizer application rates and the nutritional requirements of commercially important California crops. The agricultural areas examined were the San Joaquin Valley, the Sacramento Valley, the Salinas Valley, and portions of Orange, San Bernardino, and Siskiyou counties. Average fertilizer application rates were determined for individual crops by agricultural region based on information from the University of California Cooperative Extension Service. Typical amounts of nutrients taken up in the above-ground biomass on a seasonal basis were determined from published experimental results. Deposition rates were determined from published species-specific deposition velocities for dry compounds and from precipitation data for wet compounds.

Results: Of the three elements examined, only nitrogen -- deposited at levels greater than 20 percent of the amount annually applied by farmers -- may have the potential to cause imbalances in soil nutrient levels. At the county level, total annual depositions of N were <1 to 14 kg per hectare per year, of S <1 to 2.4 kg per hectare per year, and of Ca 0.3 to 0.8 kg per hectare per year. The researchers estimated that atmospheric deposition could supply only 0.2 percent of the N needed for lemons in San Luis Obispo County (Salinas Valley) but up to 28 percent of that

needed for grapes in Kern County (San Joaquin Valley). Atmospheric N could provide 0.1 percent of the N needed for oranges in San Luis Obispo County and 16 percent of that needed for lettuce in Kern County. Deposition could provide up to 18 percent of the S for lettuce in Kern County and 2 percent of Ca for various crops in the state.

**Significance
and
Application:**

The findings indicate that, for most commercially important crops, there is a limited possibility that atmospheric deposition of N would be an important contributor to a buildup of soil nutrients to levels that could cause adverse effects on crop productivity. Nutrient depositions of magnitudes determined in this study (~ 15 kg N per hectare per year) could have pronounced adverse effects on plants in natural, unmanaged ecosystems, such as grasslands or forests, that are adapted to growing in nutrient-poor conditions. On a regional basis, atmospheric deposition of N and S could be an important nutrient source for crops such as lettuce that have low requirements for those elements. However, because of uncertainties in volatilization rates of N applied as fertilizer, any recommendations regarding changes in current fertilizer application practices would be premature.

**Related
Projects:**

The ARB initiated the Crop Loss Assessment Program in 1984 at the University of California, Riverside. Recent reports include *Crop and Forest Losses from Air Pollutants*, (various ARB contract numbers). The economic cost of ozone-caused reductions in crop yield were examined in *The Economic Assessment of California Field Crop Losses Due to Air Pollution* (ARB contract no. A5-105-32).

This research was conducted under contract with the University of California, Riverside (ARB Contract No. 93-334). Comments or questions can be directed to the contract manager, Brent Takemoto, by mail, FAX (916) 322-4357, phone (916) 324-2981, or e-mail: btakemot@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

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Title: *Atmospheric Deposition to Agricultural Soil*

Author: Randall G. Mutters

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Research Note 96-13: Acid Deposition Rates in California

 ARB logo

No. 96-13

December 1996

RESEARCH NOTES

California Environmental Protection Agency

Brief Reports to the Scientific and Technical Community

Air Resources Board

Research Division, John R. Holmes, Ph.D., Chief

P.O. Box 2815, Sacramento CA 95812

Acid Deposition Rates in California

New estimates of wet and dry acid deposition rates in California produced by this project using data from the California Acid Deposition Monitoring Program and the National Atmospheric Deposition Program/National Trends Network will help improve our understanding of the magnitude of acidic deposition in our state. This study was performed by Envair.

Background: Deposition of acidic air pollutants occurs via precipitation, fog, and dry deposition. Each of these processes is important in California. Both the condition of the atmosphere and that of the earth's surface control the deposition rate. Studies of geochemical cycling of air pollutants indicates the importance of both wet and dry deposition mechanisms. However, the characteristics of wet deposition are likely to be considerably different from those of dry deposition. Rainfall concentrates pollutants from large quantities of air and delivers them in irregular doses and in a manner that permits relatively simple sampling. Dry deposition, on the other hand, is a slow, continuous process. The key factors influencing dry deposition rates are the characteristics of the atmosphere, the nature of the surface, the properties of the deposition species, and the concentration of the pollutants in the air.

The calculation of deposition rates at any one location requires appropriate monitoring methods and, in the case of dry deposition, an appropriate model to be applied to the monitoring data. As part of Atmospheric Acidity Protection Program, the California Acid Deposition Monitoring Program was established in 1989 to provide information about the concentrations and

deposition rates of acidic species delivered by precipitation and dry deposition.

This study was performed to estimate the deposition rates of certain pollutant species (such as nitric acid, nitrates, ammonium, and sulfates) at the ARB's 25 wet and 10 dry deposition monitoring locations, to generalize the estimated deposition rates to larger regions where possible, and to quantify the relative significance of wet and dry deposition in California.

Methods:

For wet deposition, precipitation chemistry data from the California Acid Deposition Program (25 sites), the National Atmospheric Deposition Program/ National Trends Network (8 California sites), and a 10-site wet-deposition network in the Sierra Nevada were used to estimate regional-scale rates of wet-deposited nitrate, sulfate, ammonium, calcium, and hydrogen ion for nine years -- 1985 through 1994. Each species' mean seasonal concentration was multiplied by the total precipitation recorded at the site during a specified interval. Deposition rates, associated error terms, and uncertainties were interpolated for 40 km x 40 km cells throughout the state. (It should be noted that these estimates do not include inputs from cloudwater and fog, which can provide a significant fraction of the wet deposition in some areas.)

Dry deposition rates were calculated for ozone, sulfur dioxide, nitric acid, nitrogen dioxide, particulate sulfate, particulate nitrate, and the reduced nitrogen species ammonia and particulate ammonium from early 1988 through April 1994. The rate of deposition of a particulate species is calculated as the product of its ambient concentration and its deposition velocity. Because a limited amount of data was available from the dry-deposition network, estimates of dry-deposition fluxes were generated only for the monitoring locations and were not generalized to broader regions. Estimates of the total magnitude of deposition were generated for the ten locations having both wet- and dry-deposition data.

Results:

Wet deposition rates of sulfate and nitrate for California were found to be less than 12 kg/ha/yr in all years (1985 through 1994) at all sites, and those of ammonium less than 5 kg/ha/yr. In comparison, wet sulfate and nitrate deposition rates in portions of eastern North America exceed 25 and 15 kg/ha/yr, and rates of ammonium and calcium deposition are less than 4 and 2.5 kg/ha/yr in almost all parts of eastern North America.

For most years, wet nitrate deposition estimates were greater in the South Coast Air Basin (SoCAB) and the southern Sierra Nevada than in other parts of California. In some areas where wet sulfate deposition is highest, such as the northwestern coast, much of the sulfate has its origin as sea salt.

The range of uncertainties for wet-deposition calculations is associated with the density of monitor distribution. Rates based on data obtained using a reasonably dense network of stations are subject to potentially small uncertainties. Uncertainties of wet-deposition calculations are less than or equal to 20 percent in the SoCAB, which has a large number of monitors. In some other areas, uncertainties are as large as 40 percent (southern

California) and 60 percent (northern California) for sulfate, sulfate not including sea salt, and nitrate.

During the period May 1988 through April 1994, the estimated dry deposition of nitric acid ranged from 1 to 86 kg/ha/yr. At the urban sites, nitric acid deposition accounts for 30 to 80 percent of the dry deposition of oxidized nitrogen species and 20 to 70 percent of the total nitrogen dry deposition. NO_x is the precursor to nitric acid formation; the comparison of deposition rates and emissions estimates shows that the calculated deposition rates of oxidized nitrogen species at the SoCAB stations range from 16 to 37 percent of the NO_x emission rate within the SoCAB. The estimated nitrogen deposition rates at Bakersfield and Sacramento are about 76 and 32 percent, respectively, of the NO_x emission rates in Kern County and the area around Sacramento County. Transport of NO_x from upwind areas could account in part for the relatively large deposition-to-emissions ratio at Bakersfield.

The sum of wet- and dry- deposition rates for nitrogen at the Fremont sampling site in the San Francisco Bay Area air basin is about 11 percent of the NO_x emission rate occurring within that basin. Comparison of wet- and dry-deposition data for three nonurban sites (Gasquet, Yosemite, and Sequoia) indicates that the wet deposition rates of nitrate and sulfate equal or slightly exceed the dry deposition rates of oxidized nitrogen and sulfur species. In contrast, rates of dry deposition of sulfur at the seven urban sites were one to three times greater than wet deposition rates. Dry deposition rates for oxidized nitrogen species at the urban sites ranged from about 10 to about 35 times wet deposition rates for nitrate. At all sites, dry deposition rates for reduced nitrogen species (ammonia and particulate ammonium) were greater than those for wet deposition of ammonium by about a factor of two.

Conditions in California are different from those of locations where acidic deposition is principally due to wet sulfate deposition. Across the state, the deposition of nitrogen-derived acidic gases and particles provides the main portion of atmospheric acidity and nitrogen to urban landscapes, and possibly to mid-elevation forests (elevation 1000 to 2000 m) in southern California.

**Significance
and**

Application: This study has increased our understanding of acidic deposition rates in California. The results of this project will help guide the ARB in setting atmospheric acidity and/or deposition standards, should they become necessary.

**Related
Projects:**

The ARB has sponsored these related projects (ARB contract number in parentheses): *Dry Deposition onto Aerodynamic Surfaces and Vegetation* (A6-186-32), *Measurements of Dry Deposition Parameters for the California Acid Deposition Monitoring Program* (A6-076-32), *Mathematical Modeling and Control of Dry Deposition Fluxes of Nitrogen-Containing Air Pollutants* (A6-188-32).

This research was conducted under contract with Envair (ARB Contract Nos. A132-149 and 93-332). Comments or questions can be directed to the contract manager, Nehzat Motallebi, by mail, FAX (916) 322-4357, phone (916) 324-1744, or e-mail: nmotalle@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

National Technical Information Service
5285 Port Royal Rd
Springfield VA 22161
Request NTIS No. PB94-207677

Title: *Regional Estimates of Acid Deposition Fluxes in California for 1985-1994*

Author(s): Charles L. Blanchard, Harvey Michael, and Shelley Tanenbaum

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Research Note 97-5: Topic = Nitrogen-containing air pollutants, effect on trees, conifers, forests



California Environmental Protection Agency

No. 97-5

May 1997

RESEARCH NOTES

Brief Reports to the Scientific and Technical
Community

Air Resources Board

Research Division, John R. Holmes, Ph.D., Chief

P.O. Box 2815, Sacramento CA 98512

Effects of Nitrogen Deposition on a Mixed Conifer Forest

This three-year study characterized the aerometric conditions at a mountain site downwind from metropolitan Los Angeles, with special emphasis on atmospheric concentrations of ozone and deposition rates of nitrogen-containing air pollutants. The study also assessed pine tree health and soil quality at the site. Measured ambient ozone concentrations reached levels that have been shown to cause injury to pine needles, and estimated annual rates of nitrogen deposition were low to moderately high. The effect of nitrogen deposition on soil nutrient processes was examined with a simulation model calibrated for the site. At present, it does not appear that adverse, irreversible effects of nitrogen on vegetation and soil have occurred at the site, but the long-term outlook is uncertain given the elevated levels of ozone that occur there. This study was conducted by the U.S.D.A. Forest Service and Desert Research Institute.

Background: Throughout the year, mixed conifer forests in the San Bernardino mountains are exposed to elevated levels of ozone and nitrogen-containing pollutants generated in the urban centers of the Los Angeles metropolitan area. Studies conducted in the 1960s showed that ambient levels of ozone injured the needles of ponderosa and Jeffrey pine growing in the San Bernardino mountains, but the influence of co-deposited nitrogen-containing pollutants, namely nitric acid vapor and ammonia, has been largely unstudied. In recent years, investigations of forest ecosystem responses to air pollution indicate that the deposition of nitrogenous pollutants can have pronounced adverse effects on soil chemistry and plant nutrition. The resultant alterations in soil chemistry (e.g., depletion of calcium, magnesium, and potassium ions) could adversely affect tree health, soil microbial processes, and the quality of

adversely affect tree health, soil microbial processes, and the quality of groundwater.

To examine the combined effects of ozone and nitrogen-containing pollutants on mixed conifer forests in the San Bernardino Mountains, the U.S.D.A. Forest Service and Desert Research Institute conducted this interdisciplinary field study at Barton Flats to collect air quality, tree health, and soil chemistry data to characterize the condition of a representative forest stand subjected to these pollutants. The data were also used to calibrate and test a simulation model to project the effects of elevated nitrogen deposition on soil nutrient cycling at the site.

Methods:

An aerometric monitoring station and three pine tree survey plots were established at Barton Flats (elevation 2,000 meters) in the San Bernardino mountains. Barton Flats lies near the midpoint of a west-to-east gradient of decreasing ozone concentration. Monitoring sites to the west of Barton Flats (e.g., Camp Paivika and Crestline) receive higher exposures to ozone and nitrogen-containing pollutants, while sites to the east of Barton Flats (e.g., Heart Bar) receive lower pollutant exposures. The tree survey plots for this study were located within 1.6 km of the aerometric monitoring station.

To characterize the aerometric conditions at the site, measurements of ambient ozone concentration and a suite of meteorological parameters were made continuously from November 1991 through August 1994. In addition, acidic wet and dry deposited pollutant levels were measured weekly and once every six days, respectively, except for the 7-month period October 1993 through May 1994. Deposition of atmospheric nitrogen to trees was estimated by an inferential method (the Big Leaf Model) and two field-based procedures (foliage rinsing and analysis of throughfall). Soil condition was evaluated by excavating soil pits and characterizing the chemical composition of the organic and upper mineral layers of soil. Tree health was assessed in three tree survey plots by measuring selected growth, physiological, and structural parameters.

Results:

On summer days, gaseous and particulate pollutants from the urban-industrial area to the west are transported by upslope wind flows to Barton Flats. At night, a shift in wind direction causes downslope wind flows that bring air depleted in nitrogen oxides to the site. The lack of nitrogen oxides allows ambient ozone levels to remain near 50 ppb due to low rates of ozone scavenging. Thus, Barton Flats exhibits a diurnally flat ozone profile typical of rural forest locations in the western U.S. During the study period, hourly average ozone levels exceeded concentrations that have been shown to cause pine needle injury (60 ppb), as well as the National Ambient Air Quality Standard for ozone (120 ppb). Daily maxima were greater than 200 ppb on several occasions.

Wet deposition at Barton Flats was weakly acidic with average pH values near 5.0 in summer (June through August), and 6.5 in winter (December through February). Approximately 50 percent of precipitation events occurred in winter, and less than 20 percent occurred in summer. Nitrate and sulfate were the analytes in highest concentration, accounting for 50 percent and 25 percent of all ionic species, respectively.

and 25 percent of all tree species, respectively.

Samples of PM_{2.5} (particles with an aerodynamic diameter less than or equal to 2.5 μ m) were collected to characterize atmospheric inputs of dry-deposited gases and particles. Concentrations of PM_{2.5} were highest in summer and lowest in winter. Differences in daytime and nighttime levels were greatest for nitric acid vapor and gaseous ammonia. Daytime levels of nitric acid were two to seven times higher than nighttime levels, and ammonia levels were two-fold higher during the day than at night. These nitrogen-containing pollutant concentration data were used to estimate dry deposition fluxes of atmospheric nitrogen with the Big Leaf model.

Because of known difficulties in determining rates of atmospheric nitrogen deposition to forest landscapes, three methods were used to estimate rates at Barton Flats. Using the Big Leaf model, an inferential method widely applied in the eastern U.S., dry nitrogen deposition was estimated to be 14 kg/ha/yr. By two field-based measurement techniques, foliage rinsing and throughfall analysis, dry nitrogen deposition was calculated to range from 5 to 9 or 2 to 5 kg/ha/yr, respectively.

Chemical analyses of soil in the vicinity of the tree survey plots indicated that soils at Barton Flats contain high levels of base cations (e.g., calcium, magnesium, and potassium) that may render them relatively insensitive to adverse pH-related effects. The abundance of base cations could moderate the acceleration of soil acidification and mobilization of aluminum, which have been proposed as causal factors of air-pollution-caused forest decline in the eastern U.S. and Europe.

The pine tree foliage condition was monitored in three tree survey plots established near the aerometric monitoring station at Barton Flats. During the study period, the amount of ozone-caused needle injury increased substantially in trees growing in all three survey plots. The amount of ozone-caused needle injury coincided with the incidence of an upper needle surface injury symptom, which has been associated with freezing temperatures in winter.

The effects of simulated nitrogen deposition ranging from 2 to 96 kg/ha/yr were performed with the Nutrient Cycling Model to project forest responses at Barton Flats after 40 years. In these model runs, it was projected that nitrogen deposition rates less than 19 kg/ha/yr could lead to mineral deficiencies in the trees, and rates of 38 kg/ha/yr or higher could lead to soil nitrogen saturation and groundwater pollution by nitrate.

**Significance
and
Application:**

Exposure to ozone and nitrogen-containing air pollutants poses a moderate-to-high risk to forest health at Barton Flats in the San Bernardino mountains. While summertime ozone exposures are high enough to cause needle damage and reduce the growth of native pines (daytime average concentrations > 80 ppb), rates of total (wet plus dry) nitrogen deposition are moderate (estimates range from 2 to 14 kg/ha/yr). In this regard, critical loads ranging from 10 to 20 kg/ha/yr have been proposed to protect soil quality from the impacts of excess nitrogen deposition in selected European forests. At present, it does

Related Projects:

not appear that adverse, irreversible effects of nitrogen on vegetation or soil have occurred at Barton Flats, but the long-term outlook is uncertain given the elevated levels of ozone that occur at the site.

Previous ARB-sponsored research projects on the effects of air pollutants on ponderosa pine include controlled studies conducted at the U.S.D.A. Forest Service Tree Improvement Center in Chico, California, Shirley Meadow in the southern Sierra Nevada, and the Agricultural Experiment Station at the University of California, Riverside. At Chico, branch exposure chambers were used to investigate the effects of acidic deposition and ozone on gas exchange responses in mature branches and seedlings of ponderosa pine (contract no. A132-101 (*Gas Exchange by Pinus ponderosa in relation to Atmospheric Pollutants*) and A132-174 (*Determination of Acidic Gas and Particle Concentrations in Open-Top Field Chambers*)). At Shirley Meadow, the growth and physiological responses of ponderosa pine seedlings exposed to one or two years of ozone were evaluated (contract nos. A733-137, A833-083, and A033-056 (*Growth, Physiological, and Biochemical Responses of Ponderosa Pine (Pinus ponderosa) to Ozone*)). At Riverside, a set of physiological and growth responses were monitored in ponderosa pine seedlings exposed to acidic fog alone, or in combination with ambient ozone in open-top field chambers (contract no. A6-114-32).

This research was conducted under contract with U.S.D.A. Forest Service and Desert Research Institute (ARB contract nos. A032-180 and 92-335). Comments or questions can be directed to the contract manager, Brent Takemoto, by mail, FAX (916) 322-4357, phone (916) 324-2981, or e-mail: btakemot@arb.ca.gov. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

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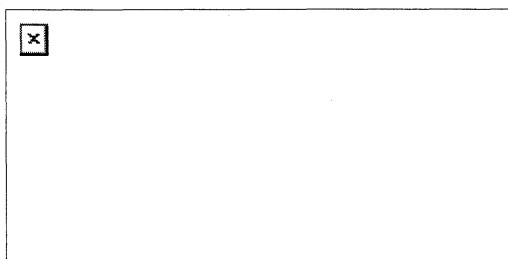
Titles: (1) *Assessment of Acidic Deposition and Ozone Effects on Conifer Forests in the San Bernardino Mountains*; (2) *Ecosystem Level Alterations in Soil Nutrient Cycling: An Integrated Measure of Cumulative Effects of Acidic Deposition on a Mixed Conifer Forest in Southern California*

Author(s): (1) P.R. Miller, J. Chow, and J.G. Watson; (2) P.R. Miller, P.J. Temple, J.C. Chow, and D.W. Johnson

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Topic = Nitrogen Saturation in the San Bernardino Mountains



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RESEARCH NOTES

Brief Reports to the Scientific and Technical
Community

Air Resources Board

Research Division, John R. Holmes, Ph.D., Chief

P.O. Box 2815, Sacramento CA 98512

Nitrogen Saturation in the San Bernardino Mountains

This project was conducted in forested watersheds located along an air pollution gradient in the San Bernardino Mountains (SBM) of southern California. Sites at the western end of the SBM experience high pollutant exposures, while sites to the east experience moderate-to-low exposures. The objectives of the project were: (1) to measure nitrogen deposition from fog and throughfall (rain that deposits on tree foliage before dripping to the ground), (2) to measure nitrate levels in streams draining from the watersheds, and (3) to quantify nitric oxide fluxes from forest soils. Fog was found to be an important source of nitrogen at the western end of the SBM. Throughfall analyses confirmed the importance of dry deposition as a major source of atmospheric nitrogen in the SBM. At the western end, stream water nitrate levels in winter peaked at 350 $\mu\text{eq/L}$, compared to less than 200 $\mu\text{eq/L}$ at the eastern end. Annual fluxes of nitric oxide from soils were 18 times higher at the western end of the SBM than at the eastern end. These data provide evidence of forest nitrogen saturation caused by the deposition of anthropogenic pollutants over a multi-decade period in the SBM. This study was conducted by U.S. Forest Service scientists.

Background: In the 1980s, researchers studying the effects of acidic deposition on forests reported that anthropogenic emissions of nitrogen-containing compounds could adversely affect forest soils and vegetation. These effects were similar to those caused by sulfur-containing compounds in the eastern U.S. That is, chronic nitrogen deposition could accelerate soil acidification, deplete levels of essential alkaline cations, and reduce tree growth. Because forest soils are typically nitrogen-deficient, it was hypothesized that after several decades of high nitrogen deposition, nitrogen levels in selected forest soils would be present in excess of that needed to sustain healthy rates of tree growth. Once forest soils became nitrogen-saturated, a set of responses indicative of forest deterioration caused specifically by excess nitrogen would become evident. In addition to loss of alkaline cations and nitrate to deep layers of soil and groundwater, elevated levels of nitrate in streams draining from

affected forests and high rates of nitric oxide emissions from soil would be detectable. Evidence of these responses would indicate that the forest had changed from being nitrogen-deficient to being nitrogen-saturated.

In consideration of findings from a project conducted at Barton Flats during the period 1991-1994, questions were raised as to the total amount of nitrogen being deposited to forests at the more polluted western end of the SBM. At Barton Flats it was found that pine trees were exposed to harmful concentrations of ozone (daytime 12-hour average ~ 0.06 ppm) and moderate levels of atmospheric nitrogen deposition (5 to 9 kg/ha/yr). Much higher exposures to both pollutants were expected to occur at the western end of the SBM, as well as more severe tree injury from ozone and adverse effects on soil nutrient cycling. This project was conducted to determine whether forest sites located at the polluted end of an ozone and atmospheric nitrogen exposure gradient in the SBM exhibited signs of nitrogen saturation. The field work was initiated in winter 1995 and concluded in winter 1997.

Methods:

Fog was collected at Camp Paivika and Barton Flats at weekly intervals to characterize fog chemistry at a western, high deposition site, and an eastern, moderate-to-low deposition site, respectively, in the SBM. Throughfall was collected on an event basis using bulk deposition collectors at Camp Paivika and Barton Flats. Stream water samples were collected monthly at 19 sites to assess trends in nitrate concentrations. Seven streams were located in Devil Canyon near Camp Paivika, and twelve sites were in the San Gorgonio Wilderness near Barton Flats. Within the San Gorgonio Wilderness, samples were collected at five southwestern sites (moderate nitrogen deposition), and at seven northern sites (low nitrogen deposition). Soil nitric oxide emissions were measured monthly at Camp Paivika and Camp Osceola, a low nitrogen deposition site about 4 km east of Barton Flats.

Results:

In fog, peak nitrogen concentrations were 4 to 5 times higher, and annual rates of nitrogen deposition were 13 to 14 times greater at Camp Paivika than at Barton Flats. At these rates of deposition, fog is an important source of nitrogen to forests at the western end of the SBM, but not at the eastern end.

Throughfall volume was 32 times greater at Camp Paivika than at Barton Flats during the sampling period. In addition, concentrations of nitrate and ammonium were 4 and 12 times higher, respectively, at Camp Paivika than at Barton Flats. Annual rates of total nitrogen deposition were estimated to be ~32 kg/ha/yr at Camp Paivika, similar to rates reported at sites where nitrogen saturation has occurred. (Note: total nitrogen deposition at Barton Flats was estimated to be ~5 kg/ha/yr.)

Consistent with expected differences in atmospheric nitrogen deposition, streams draining Devil Canyon had a higher median nitrate level (61 µeq/L) than either subgroup of sites in the San Gorgonio Wilderness. The difference in stream water nitrate levels between Devil Canyon and the San Gorgonio Wilderness was due in part to higher nitrate levels in springs at the respective sites, which have received vastly different amounts of atmospheric nitrogen over the last 30-40 years. In the San Gorgonio Wilderness, the five southwestern streams exhibited a higher median nitrate level than the seven northern streams (19 vs. 0.2 µeq/L).

Emissions of nitric oxide were substantially higher at Camp Paivika than at Camp

EMISSIONS OF NITRIC OXIDE WERE SUBSTANTIALLY HIGHER AT CAMP PAIVIKA THAN AT CAMP OSCEOLA, located about 4 km east of Barton Flats. The investigators estimated that the annual nitric oxide emissions from Camp Paivika were 4.5 kg N/ha/yr and those at Camp Osceola 0.25 kg N/ha/yr.

**Significance
and
Application:**

Throughout the SBM and other forested areas in southern California, pine trees are exposed to harmful levels of ozone and nitrogenous pollutants throughout the growing season. Previous studies conducted at Barton Flats indicated that soils at the site were not nitrogen-saturated, but may be at sites to the west, where exposures to ozone and nitrogenous pollutants are much greater. The findings from this study provide evidence of nitrogen saturation at Camp Paivika, a site that is 42 km west of Barton Flats. It is estimated that nitrogen losses due to stream water runoff and soil emissions are of similar magnitude to inputs from atmospheric deposition, a clear sign that the soil at Camp Paivika is nitrogen-saturated. The long term outlook for pine forests at the western end of SBM is not promising unless major reductions in ozone exposure and nitrogen deposition are achieved.

**Related
Projects:**

Previous ARB-sponsored research projects on the effects of air pollutants on ponderosa pine include controlled studies conducted at the U.S. Forest Service Tree Improvement Center in Chico, California, Shirley Meadow in the southern Sierra Nevada, and Barton Flats in the SBM. ARB contract numbers are given in brackets. At Chico, branch exposure chambers were used to investigate the effects of acidic deposition and ozone on gas exchange responses in mature branches and seedlings of ponderosa pine (*Gas Exchange by Pinus ponderosa in Relation to Atmospheric Pollutants* [A132-101] and *Determination of Acidic Gas and Particle Concentrations in Open-Top Field Chambers* [A132-174]). At Shirley Meadow, the growth and physiological responses of ponderosa pine seedlings exposed to one or two years of ozone were evaluated (*Growth, Physiological and Biochemical Responses of Ponderosa Pine (Pinus ponderosa) to Ozone* [A733-137, A833-083, and A033-056]). At Barton Flats, a three-year study was conducted to measure ozone concentrations, estimate rates of nitrogen deposition, and assess pine tree health and soil quality (*Assessment of Acidic Deposition and Ozone Effects on Conifer Forests in the San Bernardino Mountains* [A032-180] and *Ecosystem-Level Alterations in Soil Nutrient Cycling: An Integrated Measure of Cumulative Effects of Acidic Deposition on a Mixed Conifer Forest in Southern California* [92-335]).

To further examine the long-term effects of air pollution on pine tree health, a two-year study to identify biochemical changes in pine tree wood will be conducted by a team of researchers from the University of California, Davis, and the U.S. Forest Service. Tree cores will be collected from forests along known gradients of ambient ozone exposure in southern California and the Sierra Nevada and analyzed using pyrolysis/gas-chromatography/mass-spectrometry and Fourier-transform infrared microspectroscopy. The study, which will be completed in July 2000, is entitled *Historical-Scale Biochemical Markers of Oxidant Injury and Exposure in Pines*, ARB contract number 97-309.

This research was conducted under contract with U.S. Forest Service (ARB Contract No. 95-329). Comments or questions can be directed to the contract manager, Brent Takemoto, by mail, FAX (916) 322-4357, [e-mail](#), or phone, (916) 324-2981. For an index of Research Notes, call (916) 445-0753 or FAX (916) 322-4357.

Copies of the research report upon which this Note is based can be ordered from:

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Title: *Air Pollution and Changes in Forest Nitrogen Status: Fog and Rain Deposition and Nitrogen Losses from Forested Watersheds in the San Bernardino Mountains .*

Authors: Mark E. Fenn and Mark A. Poth

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